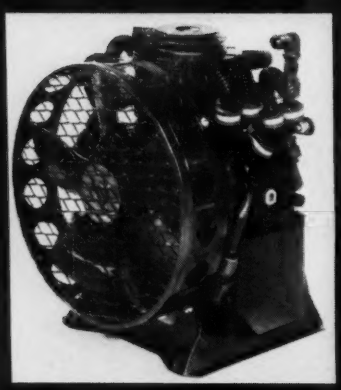
# Aeronautical Engineering REVIEW

July, 1956



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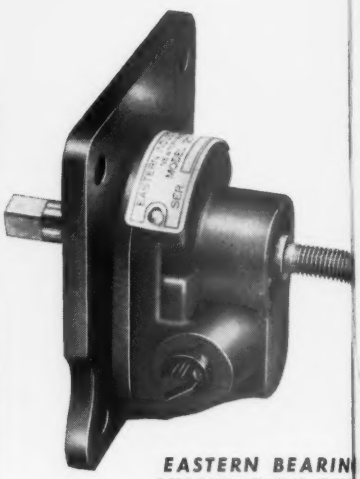

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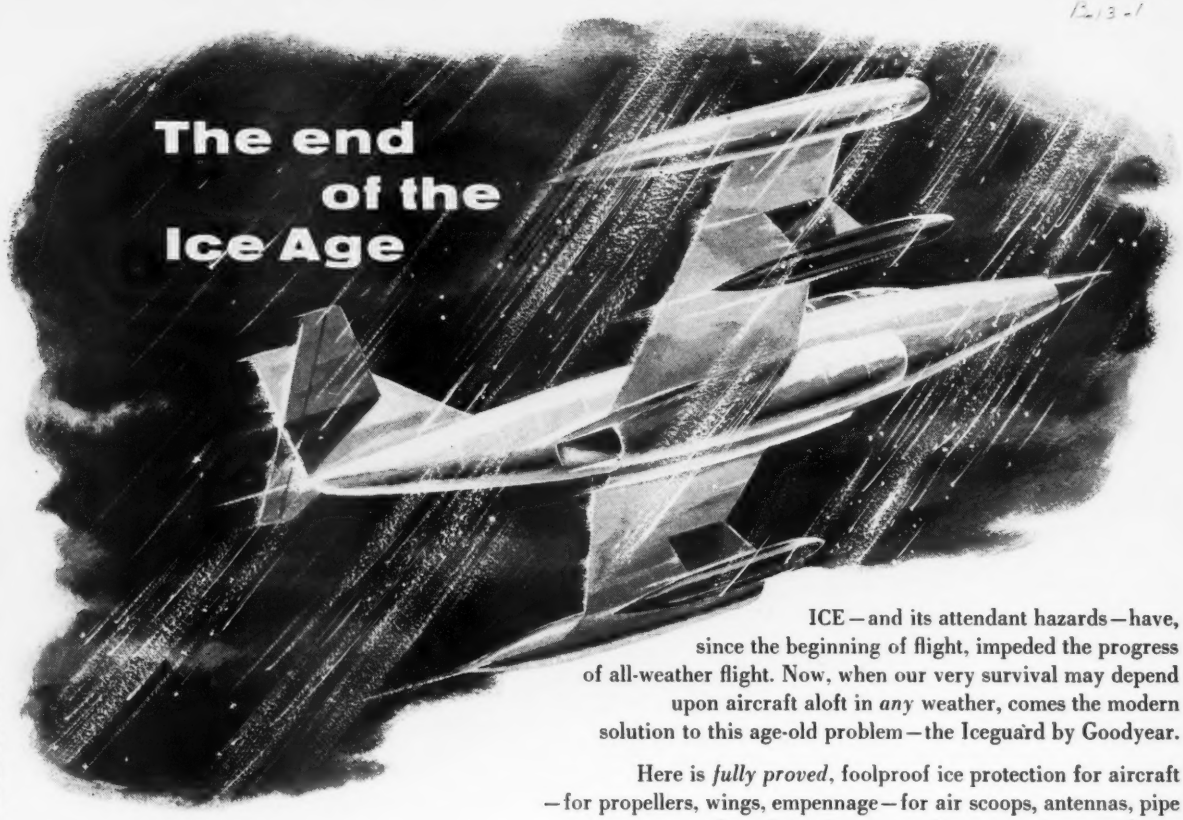
# The end of the Ice Age



ICE—and its attendant hazards—have, since the beginning of flight, impeded the progress of all-weather flight. Now, when our very survival may depend upon aircraft aloft in *any* weather, comes the modern solution to this age-old problem—the Iceguard by Goodyear.

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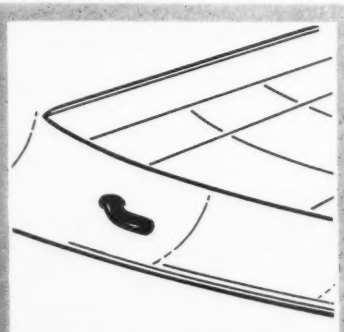
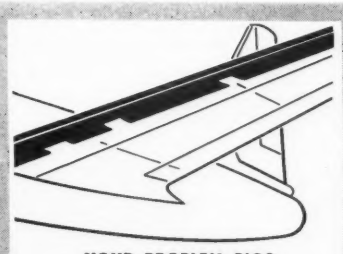


**YOUR PROBLEM SMALL?**

Here, for relief tubes, is an Iceguard 2⅝ inches small—made of *electrically conductive rubber.*



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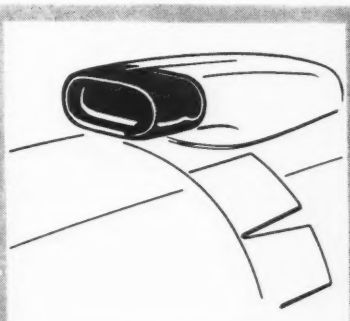

**YOUR PROBLEM SHAPE?**

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# Aeronautical Engineering Review

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**Cover**—Lockheed's supersonic XF-104, prototype of the F-104A Starfighter, shown on a test flight over the Southern California desert. The new jet plane has extremely thin, stubby wings and a T-shaped tail. The tail has no elevator; the entire horizontal stabilizer moves as a unit. Now in production at Lockheed's California Division, the F-104A is powered by the General Electric J79 engine.


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HEAT that could buckle an aircraft's skin
The engine compartment of McDonnell Aircraft Corporation's F-101A *Voodoo* is protected with J-M structural insulation. This new long-range fighter was recently ordered into quantity production by the Air Force.

## . . . safely controlled by new Johns-Manville structural insulation

**New Problems.** The engine compartment of today's jet aircraft is a "hot spot" both literally and figuratively. Not only are engine temperatures rising higher; greater speeds have produced higher air flow velocities and complex pressure problems. These new conditions call for a radical departure in insulation design.

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## N.A.T.O. TRAINING CENTER FOR EXPERIMENTAL AERODYNAMICS

### August 1 is the Deadline for Entering Students

A Training Center for Experimental Aerodynamics has been established by the Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization, at Rhode-Saint-Genese, Belgium, with the support of the Belgian Government.

PURPOSE. The aim of this Center is to provide engineers of the NATO countries with a sound training in the techniques and practices of a modern aerodynamics laboratory. With the training contemplated, the engineers should be qualified to work efficiently in all fields where a knowledge of experimental aerodynamic techniques is required. In particular, they should be fully qualified to serve as experimental engineers in aerodynamic laboratories or testing centers; and further, they should be able to act as links between design divisions and laboratories performing research in aerodynamics and fluid mechanics.

TUITION will be free of charge. Travel and living expenses will be borne by the student or by his sponsoring government or establishment. AGARD is, however, considering the possibility of providing a limited number of scholarships in special cases.

ENTRANCE REQUIREMENTS. An American student is required to have a Master of Science degree or an Engineering diploma. All candidates should have a knowledge of elementary aerodynamics and be conversant with at least one of the two languages -- French and English -- in which instruction will be given. The number of places available is limited, and selection for them from among the applicants is vested in an AGARD committee. The selection of a candidate will depend on the assessment by this committee of his background, experience, and potentiality for profiting from the course.

APPLICATIONS. Candidates should apply to the AGARD Secretariat, Palais de Chaillot, Paris 16e, France. Cable or air mail is suggested, as applications will not be accepted after August 1. Each candidate will receive two application blanks to be filled out. One completed application form should be returned to the AGARD Secretariat in Paris; the other should be mailed to one of the AGARD National Delegates in the applicant's country. The National Delegates for the United States are Hugh L. Dryden, Director of the National Advisory Committee for Aeronautics, 1512 H Street, N.W., Washington 25, D. C., and Theodore von Karman, 1501 South Marengo Avenue, Pasadena 5, California. Candidates will be informed whether they have been accepted by September 1.

THE TRAINING CENTER was established at the instigation of the Chairman

of AGARD, Dr. von Karman, who is an Honorary Fellow of the Institute of the Aeronautical Sciences. Noting that the facilities of the Rhode-Saint-Genese laboratories were not being fully utilized, he suggested in 1955 that they could be usefully adapted to the training of specialists in experimental aerodynamics. The laboratories are located in a suburb of Brussels.

EACH COURSE will last about 9 months. Laboratory work will constitute the major part of the course, supplemented by lectures to provide the necessary theoretical background. Consultants will be invited to the Center to lecture on specialized topics and techniques. Students will be given every assistance to extend their knowledge of the theoretical aspects of their subject and will be encouraged to develop research interests. A diploma will be issued to students who complete the course successfully.

* * * * * *

## NATIONAL MEETINGS CALENDAR

| | |
|---|---|
| Aug. 15-17 | Turbine-Powered Air Transportation Meeting, U. S. Grant Hotel, San Diego, California. Exhibits at IAS Building. |
| Aug. 16 | IAS Dinner, U. S. Grant Hotel, San Diego, California. |
| Nov. 26-27 | International Meeting of the Canadian Aeronautical Institute and the IAS, Royal York Hotel, Toronto, Ont., Canada. |
| Dec. 17 | Wright Brothers Lecture, U.S. Chamber of Commerce Building Auditorium, Washington, D. C. |
| Jan. 28-31 | Twenty-Fifth Annual Meeting, Sheraton-Astor Hotel, N. Y. |

## JOINT MEETINGS CALENDAR

| | |
|---|---|
| Aug. 20-21 | National Telemetering Conference, Biltmore Hotel, Los Angeles. Cosponsored with AIEE, IRE, and ISA. |

## SECTION MEETINGS CALENDAR

| | |
|---|---|
| July 10 | Los Angeles Section: Specialist Meeting, IAS Building, 8 p. m. "Fuel System Icing" by E. R. Schuberth. |
| July 18 | Texas Section: Engineering Auditorium, Arlington State College, 8 p. m. "Atomic-Powered-Aircraft Problems" by Lee Secrest. |
| July 24 | Los Angeles Section: Specialist Meeting, IAS Building, 8p. m. "Some Structural Methods and Materials for High-Temperature Applications" by Robert R. Johnson. |
| Aug. 14 | Los Angeles Section: Confidential Specialist Meeting, IAS Building, 8 p. m. "The Effect of Fuselage Flexibility on the Longitudinal Stability of a Guided Missile" by N. J. Ryker, Jr. |

* * * * * *

# IAS News

*A Record of People and Events of Interest to Institute Members*


## Turbine-Powered Air Transport Meeting

### *Program Announced for Third National Conference to Be Held in San Diego, August 15–17*

SCHEDULED IN CALIFORNIA for the first time, the 1956 National Turbine-Powered Air Transportation Meeting will be held in San Diego, August 15–17. Headquarters will be in the U. S. Grant Hotel. For the past 2 years, this meeting has been held in Seattle.

More than 600 delegates are expected to attend the 3-day conference, according to Earl R. Hinz, AFIAS, General Chairman. Last year's Turbine-Powered Air Transportation Meeting attracted a registration of approximately 500.

Highlight of the social program will be a dinner at which the principal speaker will be Major Gen. Brooke E. Allen, USAF, Commander, Continental Division, Military Air Transport Service. IAS President Edward R. Sharp will be Toastmaster. The dinner will be held in the Palm Room of the U. S. Grant Hotel on Thursday evening, August 16.

Peter G. Masefield, Managing Director of Bristol Aircraft Limited, a subsidiary of The Bristol Aeroplane Company Limited, of Bristol, England, will speak at a luncheon on Wednesday, August 15. Mr. Masefield, an Honorary Fellow of the IAS, addressed the same group in Seattle last year. Another luncheon is scheduled the following day.

**William C. Keller**

▶ A new feature in this year's program will be a score of industrial exhibits presented by Corporate Members at the IAS Building, 3380 North Harbor Drive, San Diego. Bus service will be provided between the hotel, where the technical sessions will be held, and the IAS Building. The last afternoon will be devoted to a tour of the IAS Building and exhibits and an inspection of turbine-powered transport aircraft that will be flown in to the adjacent airport, Lindbergh Field.

Five technical sessions have been scheduled as follows:

*Wednesday, August 15*—"The Introduction of Turbine-Powered Transports into Scheduled Service" will be the general subject of both the morning and afternoon sessions. The Chairman will be William Littlewood, FIAS, Vice-President for Equipment Development, American Airlines, Inc., Washington, D.C. The first day's program will close with a panel discussion in which all speakers of both sessions will participate.

*Thursday, August 16*—Morning session: "Noise Associated with Turbine-Powered Transports." The Chairman will be Thomas L. K. Smull, AFIAS, Chief of Research Coordination, NACA, Washington, D.C.

Afternoon session: "Operational Considerations with Turbine-Powered Transports." R. Dixon Speas, AFIAS, New York Aviation Consultant, will be Chairman.

*Friday, August 17*—Morning session: "The Future for Mass Air Transportation." The Chairman will be Ralph L. Bayless, AFIAS, Chief Engineer of the San Diego Division of Convair, A Division of General Dynamics Corporation.

Mr. Hinz, who heads the committee of 25 members, is Chairman of the IAS San Diego Section and Chief of Systems and Controls, Engineering Division, Ryan Aeronautical Company. Charles Blake, MIAS, of Convair, is Cochairman. James C. Kerns, AMIAS, of Ryan, is Secretary of the Committee.

William C. Keller, of Convair, heads the Program Committee, which includes Harvey Tafe, Dan Applegate, Jack Mason, and Glen Karel. Mr. Applegate is directing the work of the Exhibit Committee.

Philip M. Klauber, of Solar Aircraft Company, is Chairman of the Hospitality Committee. On his staff are Jack Porterfield, Frank W. Fink, James Woodward, James Wenzel, and Dwight Bennett.

John D. Donaldson, of Convair, is Publicity Chairman, assisted by Cyrus W. Greeves, Nelson Fuller, William Brotherton, Thomas B. Robertson, Edward Austin, and Thomas G. Stanberry.

The Financial Committee consists of Frank E. McCreery, of Rohr Aircraft Corporation, Chairman, and Robert S. Winter.

Requests for hotel reservations should be addressed directly to the U. S. Grant Hotel, San Diego 12, Calif.

**Earl R. Hinz**

# Thirteen Colleges Represented at Texas Section's Fourth Southwestern Student Paper Competition

**Here are the winners in the Texas Section's Student Paper Competition. *Left to right:* J. M. Cobb, University of Utah; W. A. Wickstrom, University of Colorado; Richard F. Weick, Texas A & M; D. T. Higdon, University of Kansas; J. T. Kevorkian, Georgia Tech; and G. G. Luesson, University of Wichita.**

The Texas Section's Fourth Annual Student Paper Competition took place April 19–21 at the Adolphus Hotel, Dallas. Seventeen undergraduate and graduate students representing 13 colleges and universities throughout the South and Midwest presented papers on aeronautical subjects.

The cost of the competition was underwritten by four local aircraft companies: Bell Aircraft Corporation (Helicopter Division); Chance Vought Aircraft, Incorporated; Convair, A Division of General Dynamics Corporation (Fort Worth); and Temco Aircraft Corporation.

Following registration the previous afternoon, the Southwestern Student Conference was opened Thursday morning, April 19, by John H. Boucher, Chairman of the Texas Section. He welcomed the competing students, faculty sponsors, and guests and then introduced E. W. Robischon, Western Region Manager of the IAS, who delivered greetings from the national organization. C. J. Benner, Chairman of the Student Competition, outlined the conference events and rules.

Three undergraduate sessions and two graduate sessions occupied Thursday afternoon and all day Friday. The papers dealt with diverse subjects in the fields of structures, design, propulsion, and aerodynamics. The sessions were well attended by the students, faculty sponsors, and employees of the local aircraft companies.

At the luncheon on opening day, the speakers were Bartram Kelley, MIAS, Chief Engineer of Bell's Helicopter Division, and Frank W. Davis, AFIAS, Chief Engineer of Convair's Fort Worth Division.

Mr. Kelley stressed the challenge of engineering work. By way of illustration he described in some detail various current projects at the Bell plant.

Mr. Davis also discussed the challenge offered by the engineering profession, from both a technical and a nontechnical viewpoint. Technically, he said, the next 10 or 15 years will see the greatest challenge ever from the standpoint of materials, propulsion (including nuclear power), aerodynamics, airway traffic control, and eventually space travel. The areas of nontechnical challenge lie in the bigness of air-frame contractors, the relationship of scientists to engineers, and (for the first time) prosperity.

**Brig. Gen. Fred M. Dean, USAF, speaking at the Awards Night Dinner of the Southwestern Student Conference at the Roof Garden of the Adolphus Hotel, Dallas, Tex.**

On Friday, the luncheon speakers were I. N. Palley, AFIAS, Vice-President for Engineering, Temco Aircraft Corporation, and Raymond C. Blaylock, AFIAS, Vice-President for Engineering, Chance Vought Aircraft, Incorporated.

Mr. Palley delivered a "sales pitch" to the visiting students, describing the opportunities for professional advancement, recognition, and prestige that exist in the local air-frame companies.

Mr. Blaylock presented a breakdown of Chance Vought's engineering department that illustrated the large number and varied types of engineers required to design modern aircraft. He advised the students to be prepared to make adjustments when they take their first job, to realize the importance of team work, and to develop outside interests. He also mentioned plans to provide educational facilities that would permit engineers in the Dallas-Fort Worth area to pursue advanced studies.

A barbecue dinner for students and faculty was held Thursday evening in the Student Union Building at Arlington State College. This was followed by a specialist meeting at which A. Scott Crossfield, of North American Aviation, Inc., spoke on "High-Speed Flight Research." Mr. Crossfield was formerly a research pilot with the National Advisory Committee for Aeronautics. He flew transonic and supersonic research airplanes at the NACA's High-Speed Flight Station at Edwards AFB, Calif.

On Friday evening, a faculty-industry smoker was held with John W. Larson, AFIAS, Assistant Chief Engineer of Chance Vought, as Chairman. Faculty representatives from the competing schools and from local colleges and high schools discussed the shortage of technical personnel with representatives of the local air-frame companies. Many excellent ideas on how to combat the shortage were stimulated by this discussion. It is intended to follow up this meeting with a definite plan of action which will strive to implement these ideas.

On Saturday, a large group of students, instructors, and IAS members made a tour of the Bell, Chance Vought,

(*Continued on page 106*)

# Brown University Host to Engineering Schools at Northeastern Student Conference

The IAS Northeastern Student Conference was held at Brown University, Providence, R.I., on Friday and Saturday, April 20 and 21. Approximately 50 persons attended, including undergraduates, graduate students, and faculty members from Cornell University, Boston University, Stevens Institute of Technology, The Polytechnic Institute of Brooklyn, Massachusetts Institute of Technology, New York University, Princeton University, Rensselaer Polytechnic Institute, and Brown University.

The 2-day program included a presentation of technical papers, informal gatherings, a banquet and luncheon, and an inspection of laboratory facilities.

Among points of interest covered on the inspection tours were the Mechanical Engineering Laboratory, the Photoelasticity Laboratory, the IBM Computing Center, and the Subsonic and Transonic-Supersonic Wind Tunnels. The use of a hot-wire anemometer to investigate the shedding of vortices from a cylinder—i.e., the Kármán Vortex Street—was demonstrated with the subsonic tunnel, and a demonstration of shock-wave patterns produced by a body of revolution in a transonic test section was observed by means of schlieren apparatus at the transonic-supersonic tunnel.

At the banquet held Friday evening, the delegates were welcomed by Paul Maeder, Faculty Adviser of the Brown Student Branch; James Mears, Chairman; Paul B. Welles, Student Activities, IAS Headquarters; and R. Bruce Lindsay, Professor of Physics and Dean of the Graduate School of Brown University. Dean Lindsay addressed the group on the value of science in education.

**Thomas A. Cincotta *(left)*, of Princeton University, receives first prize in the undergraduate competition from Prof. B. K. Erdoss, of Stevens Institute of Technology.**

Because of the large number of papers to be presented, six at the undergraduate level and eight for graduate students, two competitions were run simultaneously, one for each group. These sessions were well attended, and it was felt that the quality of the papers presented was excellent.

A luncheon was held Saturday noon at which Daniel C. Drucker, Chairman of the Division of Engineering at Brown University, addressed the assembled group. Following his talk, winners of the prize paper competition were announced. Professor B. K. Erdoss of Stevens Institute of Technology made the awards to the undergraduates, and Prof. R. F. Probstein of Brown University made the graduate student awards.

Winners in the Undergraduate Division, and the titles of their papers, were: *First*, Thomas A. Cincotta, Princeton University, "The Electrolytic Plotting Tank and Its Use in Relating Viscid and Inviscid Flows over Two-Dimensional Airfoils"; *Second*, Edmund C. Lary, Brown University, "Theoretical Investigation of Flow About an Annular Pod"; *Third*, John R. Bathrick, Brown University, "Experimental Investigation of Flow About an Annular Pod."

The following graduate students won prizes: *First*, Hans U. Thommen, Brown University, "Some Results of Linearized Transonic Flow About Slender Bodies"; *Second*, Brian M. Lempriere, Polytechnic Institute of Brooklyn, "Creep Deformation of a Circular Ring"; *Third*, Martin Fiebig, Cornell University, "The Laminar Boundary Layer on a Rotating Inclined Cone in Supersonic Flow."

**A. D. Wood, of Brown University, discusses with visiting students some of the models used for study and experimental work in the university's transonic wind tunnel.**

JAMES MEARS
*Chairman, Student Branch*
*Brown University*

# Atlanta Section Sponsors Southeastern Regional Conference at Georgia Tech for IAS Student Branches

The seventh annual Southeastern Regional Conference for Student Branches of the IAS was held April 26 and 27 at Georgia Institute of Technology, Atlanta, Ga. This year, the conference was sponsored for the first time by the Atlanta Section of the IAS. Host for the conference was the Student Branch of the University of Alabama. Twenty-one undergraduate and graduate students, representing nine colleges and universities throughout the Southeast, delivered papers on aeronautical subjects.

Several Southeastern companies supported the conference by underwriting some of the travel and housing expenses of the students. The companies were Delta Air Lines, Inc., Hayes Aircraft Corporation, Lockheed Aircraft Corporation, and Southern Airways, Inc.

The 2-day conference consisted of four technical sessions, an inspection tour of Air Force Plant No. 6 operated by Lockheed Aircraft Corporation, an Awards Night Banquet, luncheons, and other informal gatherings. Opening with registration on Thursday morning, April 26, the conference got under way officially at 9:00 a.m. when A. L. Ducoffe, Chairman of the Atlanta Section of the IAS, called the conference to order. He was followed by Robert S. Chubb, General Conference Chairman, who outlined the events to follow and the rules of competition and introduced the student chairmen of the various technical sessions. These chairmen were William N. Caudle, Chairman of the Student Branch of the University of Alabama; James O. Nichols; Charles C. Church; and Jerry C. Bates.

At the luncheon on Thursday, Colgan H. Bryan, Head of the Department of Aeronautical Engineering of the University of Alabama, gave the welcoming address and outlined the expansion of the aircraft industry and associated businesses in the Southeastern area.

On Friday, April 27, the students and faculty were the guests of the Lockheed Aircraft Corporation for luncheon in the plant cafeteria. Dan J. Haughton, Vice-President and General Manager of the Georgia Division, welcomed the conference representatives to the plant and listed briefly some of the latest developments started by Lockheed in Georgia. The luncheon was followed by a tour of the production line and test facilities and by a flight demonstration of several aircraft.

At the banquet Friday night the speaker was Rear Adm. Luis de Florez, USN (Ret.), pioneer naval aviator and IAS Fellow. Admiral de Florez covered some of the problems allied with aircraft operations—namely, ground handling and delays and inconveniences in going to and from airports. The banquet was concluded by presentation of the awards to the winning authors.

**Delegates to the Southeastern Regional Student Conference watch a high-speed flyover by a B-47 jet bomber during a tour of the Lockheed Aircraft Corporation plant in Marietta, Ga.**

*First prize* for the best undergraduate paper was won by Gerald D. Walberg, Virginia Polytechnic Institute, for his discussion of "Investigation of Base Pressure on Bodies of Revolution in the Transonic Range." *Second prize* was won by William P. Harrison, Jr., Virginia Polytechnic Institute, for his paper on "Some Considerations of Pressure Drag over the Front Surface of Two-Dimensional Wedges Having Different Afterbody Configurations." *Third prize* went to Francis L. Pugh of Alabama Polytechnic Institute for "Radio Control of Model Aircraft."

*First prize* for graduate papers went to Thomas H. Clore, University of Kentucky, for his paper entitled "The Continuous Disreefing of Parachutes." *Second prize* was awarded to Wesley M. Mann, Georgia Institute of Technology, for his discussion of "The Effect of Large External Stores on the Low-Speed Longitudinal Aerodynamic Characteristics of a 60° Delta Wing and Fuselage Combination."

The prizes were furnished by the Minta Martin Aeronautical Student Fund established by the late Glenn L. Martin. The winning papers will be included in the 1956 edition of *First Award Papers* which will be published under the auspices of the Minta Martin Fund.

The schools represented at the conference were Alabama Polytechnic Institute, University of Alabama, Georgia Institute of Technology, University of Florida, University of Kentucky, Mississippi State College, U.S. Naval Academy, North Carolina State College, and Virginia Polytechnic Institute.

The total attendance at the conference exceeded all previous years by about 50 per cent, numbering approximately 150. Judges included C. F. Friend, Head of Aerodynamics at the Lockheed Aircraft Corporation; John Meshejian, Chief Technical Engineer at Hayes Aircraft Corporation; and Walt Overend, Engineering, Delta Air Lines, Inc.

Among visitors at the conference were Paul B. Welles, of Student Activities, IAS Headquarters, and Capt. R. E. Stieler, USN, Commanding Officer of the Naval Air Station at Atlanta.

The conference closed with an expression of appreciation to the Atlanta Section of the IAS, the Alabama Student Branch, and the sponsoring companies. It was agreed that the growing attendance at these conferences was indicative of increased interest and technical capability in the aeronautical sciences within the Southeastern region.

ROBERT S. CHUBB
*General Conference Chairman*
*Atlanta Section*

## Flight Safety Officials

Four members of the IAS have been elected to the Board of Governors of the Flight Safety Foundation, Inc., which is headed by Rear Adm. Luis de Florez, USN (Ret.).

The new Board members are Grover Loening, FIAS, a Founder and Benefactor of the Institute; Brig. Gen. Harold R. Harris, USAF (Ret.), FIAS; T. F. Walkowicz, MIAS; and Fred M. Glass, AMIAS.

## Employee Relations

James B. Rea, AFIAS, President of the J. B. Rea Company, Inc., Santa Monica, Calif., is trying to encourage the stork to deliver some future electronics engineers.

He celebrates the birth of a baby by handing a crisp $100 bill to every employee who becomes a parent. Seven fathers have been honored to date.

# University of Maryland Draws Five Schools to First Middle Atlantic Student Conference

The Institute's first annual Middle Atlantic Student Conference, held at the University of Maryland, College Park, on April 13 and 14, was attended by 60 students and faculty members representing five engineering schools.

The competing students delivered their papers on the first day, and the banquet was held the same evening. The next day's activities consisted of a tour of the University of Maryland Engineering School's facilities and a business meeting. The purpose of the student paper competition was to encourage student members to undertake original technical investigations and to give them practice in presenting technical papers orally before a group.

The conference began with registration from 8:00 to 11:00 on Friday morning. At 11:00 the conference was officially opened by the President of the University of Maryland Student Branch, Charles Stouffer. Mr. Stouffer then introduced S. S. Steinberg, Dean of Engineering at the Glenn L. Martin Institute of Technology of the University of Maryland. Dean Steinberg presented the opening talk in which he welcomed the conference to the University of Maryland campus.

Following lunch, the technical session was held. The following papers were presented before the intermission: "Metal-to-Metal Bonding" by Paul D. Fisher and Stanley T. Corbett, University of Maryland; "Prospects of Atomic-Powered Rocket Propulsion" by Midshipman R. L. Blackner, U.S. Naval Academy; and "Some Effects of Supersonic Jet Streams Exhausted over Thin Curved Airfoils" by Stanley T. Piszkin and Charles Stouffer, University of Maryland.

A group photograph was taken during the intermission. Then these papers were presented: "A Comparison of Methods of Determining the Flow About a Body" by Herbert E. Hunter and Robert L. Velebny, University of Maryland; "The Effective Thickness of Built-Up Flanges Subjected to Crippling Loading" by Charles O. Johnson and Edward C. Wood, University of Maryland; "Investigation of the Effects of Trailing-Edge Roughness on the Drag Characteristics of the NACA 0015 Airfoil" by Tunney Oydna and Juri Kork, University of Maryland; and "The Effects of a Canard-Type Tail on the Spanwise Lift Distribution of the Wing" by John C. Gucek and Frank Bastidas, The Pennsylvania State University.

The banquet was held at seven o'clock Friday night. The awards were presented to the winning authors at the banquet by Paul B. Welles, of IAS Student Activities. *First Prize* went to Charles Stouffer and Stanley Piszkin, University of Maryland; *Second Prize* to Charles Johnson and Edward Wood, University of Maryland; and *Third Prize* to John C. Gucek and Frank Bastidas of The Pennsylvania State University. The prize money was furnished by the Minta Martin Aeronautical Student Fund, and the winning paper will be published in the 1956 edition of *First Award Papers*, financed by the Minta Martin Fund.

**Delegates to the First Middle Atlantic Student Conference at the University of Maryland.**

The highlight of the banquet was a talk by Max Munk of The Catholic University of America in which he pointed out that the prizes were not the major objective of the student paper competition. He then discussed the progress of aviation during his lifetime.

The Saturday morning activities started with a tour of the University of Maryland Engineering School's facilities, including the 7.75 by 11 ft. subsonic wind tunnel. After the tour, a business meeting was held at which the traveling expenses and two copies of the group picture were distributed to each of the schools. These also were obtained from the Minta Martin Fund. Mr. Stouffer asked for recommendations from the floor on how the conference might be improved. It was suggested that programs might be sent out in advance of the conference, but, since one of the big problems in holding this conference was getting prompt answers to correspondence, it was impossible to make up the schedule until just prior to the conference. It was therefore suggested that all of the schools involved in the conference make a special effort to answer correspondence promptly and that deadlines be established.

The following schools were represented at the conference: Virginia Polytechnic Institute, U.S. Naval Academy, The Pennsylvania State University, University of Virginia, and University of Maryland.

H. E. HUNTER
*Secretary, Student Branch*
*University of Maryland*

## General Dynamics Corporation Joins the Institute

General Dynamics Corporation has joined the Institute of the Aeronautical Sciences, assuming the position as a Corporate Member previously held by its Convair Division. The company's main office is at 445 Park Ave., New York, N. Y.

Two of General Dynamics Corporation's five divisions and its Canadian subsidiary, Canadair Limited, are engaged extensively in aeronautical research and development and in production.

The largest unit of the Dynamics family, the Convair Division, with plants in San Diego and Pomona, Calif., and Fort Worth and Daingerfield, Tex., recently was awarded a contract by the Air Force to develop an air frame for a

nuclear-powered plane. Flight tests to study the effects of radiation have been under way for several months with a B-36 intercontinental bomber carrying a Convair-built atomic reactor.

Convair is negotiating with commercial air lines for delivery in early 1960 of the Skylark 600 medium-range jet transport. This swept-wing, four-engined jet is designed to operate from 5,000-ft. runways and to cruise at 609 m.p.h.

Convair's 49,000 employees are producing or developing a diversified line of aircraft, guided missiles, and associated products, including the B-58 jet bomber, the F-102A all-weather supersonic jet interceptor, and the Atlas intercontinental ballistic missile.

Canadair Limited in Montreal, second largest of the Dynamics family, is engaged in production of military and commercial aircraft and guided missiles. Its largest operation is in the military field. It serves the RCAF, RAF, South African, Royal Hellenic, and Turkish Air Forces, as well as Trans-Canada Air Lines and BOAC.

Stromberg-Carlson in Rochester, N.Y., is engaged in electronics production, including the new Tacan aircraft navigational equipment.

The Dynamics family also includes the Electric Boat Division, builders of the atomic submarines U.S.S. "Nautilus" and "Seawolf"; the General Atomic Division, concerned with the corporation's long-term nuclear research; and the Electro Dynamic Division, producing electric motors of advanced design.

Galen B. Schubauer

## Schubauer Wins Gold Medal For Aerodynamic Research

Galen B. Schubauer, FIAS, Chief of the Fluid Mechanics Section of the Mechanics Division of the National Bureau of Standards, has been awarded the U.S. Department of Commerce Gold Medal for Exceptional Service. The award was given in recognition of his "outstanding contributions to basic aerodynamics over the past 20 years."

The Department said Dr. Schubauer's work on turbulence and airflow and in the development of instruments for measuring these phenomena has been vital to the development of modern high-speed aircraft. Among the recent projects of Dr. Schubauer's section was a study of the accuracy of the hot-wire anemometer at speeds up to twice the speed of sound. This instrument has been basic in aerodynamic research at subsonic speeds, but it was not known whether the hot-wire anemometer could be used at supersonic speeds.

The veteran Government scientist, who joined the NBS staff in 1929, was a joint winner of the Sylvanus Albert Reed Award for 1947. He became Chief of the Aerodynamics Section of NBS in 1946 and was promoted to his present position in 1953. He lives in Washington, D.C.

## Republic Forms Staff for Advanced Scientific Research

Republic Aviation Corporation, Farmingdale, N.Y., is forming an ultra-specialized research staff to deal with "tomorrow's problems today" in all aspects of jet and rocket combat aircraft and missiles.

President Mundy I. Peale, AMIAS, said the new Scientific Research Staff will work "in the range between pure theoretical research and applied engineering." Such problems as the thermal barrier, atomic energy applications, and hypersonic flight will be its concern, he said. It also will explore developments in such fields as mathematics, general physics, supersonics, and nuclear physics.

"Aviation is well into areas that a few years ago were unheard of," Mr. Peale said, "and we have found the need for a basic research group that will seek out and solve the problems connected with extremely advanced, hypersonic aircraft and missiles, such as Republic plans to produce, that will fly at speeds of several thousand miles an hour and reach altitudes of 50 miles over the earth while encountering temperatures ranging from subzero to 1,200° or more.

"Though this is an extremely practical industry, we are looking for some 'tomorrow' thinkers because aeronautical problems have become so complex and grown to such a size that they can not be considered purely as practical engineering problems."

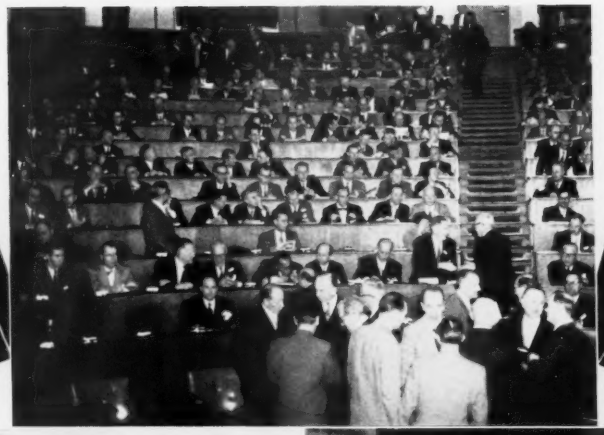
The new group will report to Alexander Kartveli, FIAS, Vice-President and Chief Engineer. It will work under supervision of Theodore Theodorsen, FIAS, Director of Scientific Research, who is noted for his development of the fundamental theory of flutter.

The company announced it is screening its own engineers for appointments to the new group and will seek other qualified candidates by advertising.

"We are searching," Dr. Theodorsen said, "for men of inventive capability who are able to produce new theories or

(*Continued on page 24*)

**Four M.I.T. men who are prominent in IAS affairs meet at the first Minta Martin Lecture. Standing *(left to right)* are William R. Hawthorne, Hunsaker Professor of Aeronautical Engineering at M.I.T., and S. Paul Johnston, Director of the IAS. Seated are Lester D. Gardner, Founder and Honorary Fellow of the IAS, and Charles S. Draper, Head of the Aeronautical Engineering Dept. at M.I.T. Mr. Gardner, Class of '98, suggested and aided in founding the Hunsaker chair. Dr. Hawthorne delivered the endowed lecture on "The Aerodynamics of Aircraft Engines" this spring at Massachusetts Institute of Technology, University of Maryland, California Institute of Technology, and Case Institute of Technology.**



# NATO Scientists Meet at AGARD Session on Guided Missiles

A delegation of American scientists, engineers, and officials concerned with the development of guided missiles attended a seminar on "The History of German Guided Missiles Development" in Munich, Germany, April 23–27. In the group were a score of IAS members, including S. Paul Johnston, Director of the Institute, and Robert R. Dexter, Secretary.

The conference, which attracted 280 delegates from nations enrolled in the North Atlantic Treaty Organization, was sponsored by NATO's Advisory Group for Aeronautical Research and Development. Most of the arrangements were handled by the Wissenschaftlichen Gesellschaft für Luftfahrt e.V. (Scientific Society for Air Travel), the German equivalent of the IAS.

Among the papers presented, all of which were unclassified, were several by German scientists who participated in developing the V-1 and V-2 rockets during World War II and several others by former German scientists who are now working in the United States on missile projects.

The photos above show two of the conference speakers, Hermann Blenk (*upper left*), Chairman of the WGL society, and Theodore von Kármán (*upper right*), Chairman of AGARD; a view of the audience; and delegates engaged in discussion or looking at the exhibit of rocket models.

The group at *lower left* includes Frank L. Wattendorf, FIAS, Director of the AGARD Secretariat; Will Ennenbach, General Secretary of WGL; Dr. Blenk; and Dr. von Kármán, who is an Honorary Fellow of the IAS.

Among IAS members present at the seminar in Munich were Sidney R. Alexander, of the Navy Bureau of Aeronautics; A. G. Baeumker, Air Research and Development Command, USAF; Seville Chapman, Cornell Aeronautical Laboratory, Inc.; Walter R. Dornberger, Bell Aircraft Corporation; Gerhardt Eber, Holloman Air Development Center; Rear Adm. Delmer S. Fahrney, USN (Ret.), Bureau of Aeronautics; Antonio Ferri, Polytechnic Institute of Brooklyn; Andrew G. Haley, President, American Rocket Society; Rudolf Hermann, University of Minnesota; C. R. Irvine, Convair, A Division of General Dynamics Corporation; Roy P. Jackson, Northrop Aircraft, Inc.; Hermann H. Kurzweg, Naval Ordnance Laboratory; Robert G. Melrose, Republic Aviation Corporation; Lt. Col. William C. Nielsen, Hq. USAF; Major Gen. James F. Phillips, USAF (Ret.), Aircraft Industries Association, Inc.; James F. Reagan, Beech Aircraft Corporation; and Edwin A. Speakman, Fairchild Engine and Airplane Corporation.

(*Continued from page 22*)

ideas, as well as for men of analytical ability to condense engineering information applicable to future and current problems." Fundamental research will be the primary concern of the group. It will be maintained on a semiacademic status, so it is "free to explore developments in such fields as mathematics, general physics, supersonics, thermodynamics, nuclear physics, and atomic energy applications, among others," he said.

Dr. Theodorsen said the staff also will keep in close touch with Governmental and industrial research institutes, including the atomic agencies. Much of its exploration in these areas will be in preparation for the company's entry into new fields connected with aeronautics.

The staff will be available to all departments for consultation, and individual members may be temporarily assigned to other engineering groups, if required.

## Necrology

### Lt. Paul D. Jacobs

Second Lt. Paul Daniel Jacobs, TMIAS, was killed February 14 when two jet trainers collided over the Gila Bend gunnery range near Williams AFB, Ariz. Lieutenant Jacobs, an Air Force pilot, was on a gunnery practice mission. He was 25 years old.

Lieutenant Jacobs joined the Institute as a student member while attending the University of Cincinnati. Receiving his B.S. degree in Aeronautical Engineering in June, 1953, he went to work for Douglas Aircraft Company, Inc., Long Beach, Calif., as a Test Engineer. He had a private pilot's license several years before graduating from college. He had been in the Air Force 2 years as an aviation cadet and pilot.

Lieutenant Jacobs is survived by his parents, Mr. and Mrs. Harry J. Jacobs, of Cincinnati, and a sister.

### Berneice H. Jarck

Miss Berneice Helen Jarck, AMIAS, former Managing Editor of the JOURNAL OF THE AERONAUTICAL SCIENCES and the AERONAUTICAL ENGINEERING REVIEW, died in a Los Angeles hospital on May 11. She was 42 years old.

Miss Jarck was employed for 13 years by the Institute of the Aeronautical Sciences. She was in charge of editorial production on the annual AERONAUTICAL ENGINEERING CATALOG, as well as on the monthly magazines.

Ill health forced her to resign a year ago from the IAS headquarters staff in New York. For the past several months, she had been employed by the Meletron Corporation, of Los Angeles, as Editor of its employee publication.

A native of Easton, Pa., Miss Jarck graduated from Easton High School and from The Pennsylvania State College, where she majored in mathematics, English, and history.

Funeral services were held in Roselle, N.J., where she had lived for a number of years. Burial was in Easton. Miss Jarck's only surviving relatives are an uncle and aunt, Mr. and Mrs. Alfred Gass, of Roselle.

### Willard A. Hoffman

Willard Albert Hoffman, AMIAS, a senior engineer in the Downey Division of North American Aviation, Inc., was killed in a skiing accident on February 26. He was 34 years old.

Mr. Hoffman, who lived in La Habra, Calif., was engaged in flight test work in the company's Missile Development Section. He had transferred to the Downey plant from North American's Columbus (Ohio) Division in May, 1955.

A graduate of Aero Industries Technical Institute, Los Angeles, Mr. Hoffman was employed by the Curtiss-Wright Corporation and Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y.; the Naval Air Test Center, Patuxent River, Md.; and the Naval Air Missile Test Center, Point Mugu, Calif., before joining North American in 1951. After a period of flight training in the Navy, he obtained a private pilot's license in 1946. The following year, he graduated from an engineering course at the Navy Test Pilot Training School, NATC.

### Edward E. Lubischer

Edward Eugene Lubischer, MIAS, of York, Pa., was killed December 21 in the crash of a Navion airplane owned by the S. Morgan Smith Company, of York. The accident occurred shortly after he took off for Washington on a business trip.

Mr. Lubischer, who was 41 years old, joined the company in December, 1952, as Pilot and Manager of Air Transportation. He was formerly an executive transport pilot for General Motors Corporation, Detroit, and Esso Standard Oil Company, Newark, N.J. He also had flown cargo transports, and he held an air-line transport pilot's rating.

During World War II, Mr. Lubischer was a Field Service Engineer for General Motors Corporation, working with the Navy in the United States, Hawaii, Guam, and Saipan and aboard aircraft carriers on the TBM torpedo bomber and the FM-2 fighter. He also served as a civilian technical adviser to the Army Air Corps.

A native of Elizabeth, N.J., Mr. Lubischer is survived by his wife, Sophia, and a daughter, Karyn.

## NEWS OF MEMBERS

▸ **E. W. Anderson** (M), Head of the Aeronautical Engineering Department at Iowa State College, has been elected an Honorary Member of Sigma Gamma Tau, national aeronautical engineering fraternity.

▸ **Squadron Leader Laurie J. Bayliss,** RAF (Ret.) (M), has been elected a Vice-President of the Gloucestershire Engineering Society, one of England's oldest engineering societies.

▸ **Erle Martin** (F), a Vice-President of United Aircraft Corporation and General Manager of Hamilton Standard Division, has joined the company's Quarter Century Club. He was presented a 25-year pin and a gold watch on May 11.

▸ **Paul Rosenberg** (M), President of Paul Rosenberg Associates, consulting physicists, received the Talbert Abrams Award of the American Society of Photogrammetry at the Society's twenty-second annual meeting in Washington, D.C.

▸ **Vice-Adm. Charles E. Rosendahl,** USN (Ret.) (F), Executive Director of the National Air Transport Coordinating Committee, has been presented a Certificate of Honor by the Air Force Association for his direction of the Committee's community relations program in metropolitan New York.

George Nichols, MIAS *(right)*, of Northrop Aircraft, Inc., receives an award from Lt. Col. John P. Stapp for his and Northrop's "pioneering contributions to aero-medical research" through design and construction of rocket sleds.

R. L. Bisplinghoff, AFIAS, Professor of Aeronautical Engineering at M.I.T., has been appointed to the Air Force Scientific Advisory Board and the NACA Committee on Aircraft Construction.

Charles H. Zimmerman, AFIAS, of Langley Aeronautical Laboratory, NACA, has been presented the Alexander Klemin Award for 1956 by the American Helicopter Society.

## *Members on the move . . . .*

*This section provides information concerning the latest affiliations of IAS members. All members are urged to notify the News Editor of changes as soon as they occur.*

**David B. Benepe** (M) has rejoined Convair's Fort Worth Division after a tour of duty with the Army at Fort Belvoir, Va. He is a Senior Aerodynamics Engineer in the Model Test Group of Convair's Experimental Aerodynamics Section.

**E. I. Bricker** (AF) has been promoted to Manager of the Mechanical and Hydraulics Test Department at Lockheed Aircraft Corporation's plant in Marietta, Ga.

**Niels C. Beck, MIAS, has gone to Rangoon as Director-General of the Union of Burma Applied Research Institute. He was Acting Manager of Program Development, Armour Research Foundation, Illinois Institute of Technology.**

**John H. Carter** (M), formerly Assistant Director of Development Planning, Lockheed Aircraft Corporation, has been appointed Associate Research Director of the company's Missile Systems Division in Van Nuys, Calif.

**Frank A. Flower** (AM), formerly Sales Engineer, has been appointed Manager of Government Sales, Thompson Products, Inc., Cleveland.

**Frank W. Godsey, Jr.** (M), has been elected a Vice-President of Westinghouse Electric Corporation. He will continue as Manager of the Westinghouse Air Arm Division, Electronics Division, and X-Ray Division in Baltimore.

**Guillermo Gonzalez Gomez** (M) has joined the Engineering Division of the Civil Aeronautics Department of Guatemala as an Aeronautical Engineer. He has been assigned to work under the ICAO Technical Assistance Mission to Guatemala, assisting in the nation's aviation development program. He was previously in the Engineering Office of San Carlos University, Guatemala City.

**Leonard S. Hobbs** (F), Vice-President for Engineering, has been elected Vice-Chairman of the Board of Directors of United Aircraft Corporation.

**Robert H. Hodges** (M) has joined Convair, A Division of General Dynamics Corporation, to work on missiles, particularly the Atlas ICBM, with the Flight Test Engineering Group. He was formerly a field service representative in California for United Aircraft Service Corporation, Pratt & Whitney Aircraft Division.

**Frank Mansur** (M) has joined Eitel-McCullough, Inc., San Bruno, Calif., as Manager of Marketing. He was formerly Manager of the Government and Commercial Department of Hazeltine Electronics Corporation, Little Neck, N.Y.

**Edwin G. Markle** (AF) has joined the Rocketdyne Division of North American Aviation, Inc., Canoga Park, Calif., as a construction engineer. He was formerly with the Bridge and Structures Design Division, Bureau of Engineering, Department of Public Works, City of Los Angeles.

**A. Elliott Merrill** (M), Flight Test Chief of the Wichita Division, Boeing Airplane Company, has been assigned to Military Sales in the company's Transport Division in Seattle. A test pilot for many years, he won the Octave Chanute Award for 1945 for his pioneering research in high-altitude flying with the Boeing B-17 and B-29 bombers.

**Norton B. Moore** (AF), formerly of McDonnell Aircraft Corporation, has joined the engineering staff of Aerophysics Development Corporation, Santa Monica, Calif.

**Paul R. Owen** (AF), of the University of Manchester, Manchester, England, has

(*Continued on page 68*)

**Howard S. Coleman, MIAS, who directed development of CinemaScope lenses for Bausch & Lomb Optical Company, has been named Manager of the Research and Engineering Division.**

# *Editorial*

## The Job Before Us

Pentagon Planners hunched over their crystal balls sometimes seem to have difficulty in deciding "What is What" and "Which is Which" in looking at the overall air defense problem. When a missile sprouts wings, does it become an aircraft? Or is an aircraft not an aircraft just because it happens to be able to get along without a human pilot aboard? Such questions will be resolved in due course by appropriate interservice agreement, but, meanwhile, quite a bit of smoke and not a little heat have been generated in what is sometimes described as "the five-sided ulcer mill" by the Potomac.

Fortunately, such problems do not concern the Planners whose responsibility it is to provide proper fare for the membership of this Institute. Although at its inception such things as "whirly birds" and wingless rockets were not integral parts of the aeronautical scene, the Founders realized that there were other possible configurations beyond the conventional machines of the period and, in their wisdom, drew our charter to cover the entire field of the "aeronautical sciences." Thus, from the beginning, the Institute has considered its responsibility clear—to service its membership in all areas that have any bearing on the science and art of aeronautics.

This mandate eliminates for all time any argument as to who does what for whom. We have always served, and we will continue to do so as far as we are able, the professional interests of all IAS members—from sail-

planes to satellites. We are concerned with the *aerial vehicle*, winged or wingless, inhabited or uninhabited, whether driven by fans, a blowtorch, or a charge of gunpowder. We are concerned with how it finds its way from place to place and with the environment through which it flies. We are interested in every element of its design that improves its efficiency or its effectiveness. We are interested in the human factors that are involved in its operation. In short, IAS interest is limited only by the needs of those we serve—our membership.

These factors are kept constantly in mind in planning our national and local meetings. It is impossible, of course, in *every* meeting to come up with something of interest to everybody, but the people who do the planning are doing their best to arrange programs of maximum interest to those who do attend. We believe that our primary mission is to provide the technical "tools of the trade" insofar as is possible within present-day security restrictions. This we will continue to do, on an across-the-board basis.

Our publication policies are being continually revised against the same criteria. Recently, the JOURNAL has been expanded in size, and its backlog of articles overhauled against revised standards of timeliness and professional need-to-know. Although they sometimes appear to be a bit "long-haired" or "too full of math" for many of us, analysis will show that over the years many of the basic concepts on which current aircraft and missile design are based were first recorded in the pages of the JOURNAL. We are particularly proud of the May, 1956, issue which commemorated the 75th birthday of Dr. Theodore von Kármán. He writes: "I want to express not only my sincere thanks but also my congratulations to the May number of the Institute JOURNAL. I am really proud that . . . my birthday gave opportunity for a publication of such an extraordinary scientific level . . . ."

The editorial coverage of the REVIEW has come in for a great deal of attention in the past few months. Reader requirements, as revealed by direct inquiry and a detailed study of areas of interest to members, have been carefully reviewed by our staff and technical advisers, and a program has been mapped for the future, consistent with these findings.

The REVIEW is an engineer's magazine. It deals with research, design, and development of aerial vehicles—manned or unmanned, winged or wingless—and of missiles, from rock to rocket. Its subject matter falls normally into four general categories—aeronautical engineering, power-plant engineering, systems engineering, and operations engineering. Such things as human engineering and electronics engineering cut across all the others. Articles are selected mainly from the huge backlog of papers presented at IAS meetings, augmented by timely and worth-while papers and reports selected directly from outstanding engineering contributions, whatever the source. Some are presented in full, some in abbreviated form, some as abstracts. Our aim is to make available to the scientists and engineers of our industry the latest available technical information in its most useful form.

We cannot afford to dilute our capabilities in this direction with any effort to cover general political or economic aspects of our industry. We leave that to the more popular, nontechnical, "news" types of publication that specialize in such areas. We intend to "stick to our own knitting." We shall keep our eyes on the job before us—the advancement of the arts and sciences of aeronautics—by servicing the technical needs of our membership to the best of our abilities.

S.P.J.

# VTOL-STOL Aircraft—Part I

*A compendium of six papers on VTOL-STOL concepts. The paper by Earl R. Hinz was written especially for the* REVIEW; *others were prepared for the IAS Annual Meeting in January. Editing and deletion of some illustrative material make possible this presentation much earlier than would be feasible if each was published in complete form in separate issues. Part II will appear in the August* REVIEW.—ED.

## Jet VTOL

Earl R. Hinz*
Ryan Aeronautical Company

POST WORLD WAR II aeronautical progress has been highlighted by many new developments which promise to be seven league boots in man's conquest of the air. The jet engine, the supersonic air frame, electronic guidance equipment, and titanium metal—to name a few—are all aiding in today's assault on time, altitude, and distance. Yet another development is on the horizon which has equally captured the public's imagination and given the military planner a new concept for mobility of operations. This is the vertical take-off and landing aircraft, more popularly known as the VTOL airplane.

Many varied and interesting types of VTOL aircraft have already been displayed, but these are not tactically useful aircraft in their present configurations since their primary objective was only to display VTOL capabilities and solve associated problems. Other approaches are also being followed on the VTOL problem which will result in a large fund of engineering knowledge to permit the construction of, first, military and, later, commercial VTOL airplanes.

But why should so much effort be expended to change the time-honored method of airplane take-offs and landings? The answer is simply that the runway type of operation is a handicap to most classes of airplanes, and their primary mission is compromised by retention of the conventional landing gear. Airports are becoming exceedingly large and so expensive that their costs are out of proportion to their intended purpose.

* Formerly, Research Group Engineer. Now, Chief of Systems and Controls, Engineering Division.

The VTOL concept will eventually free the military airplane from these burdening runway requirements and, in addition, provide a wider degree of dispersal from enemy attack. Having eliminated the need for prepared runways, the same type of airplane could then be made adaptable to shipboard use. Many classes of naval vessels are capable of carrying their own air cover or tactical striking force if the VTOL concept is applied.

Removal of the conventional landing gear may seem a bit rash at first thought. But, after all, is it any more so than substituting monoplanes for biplanes? Or jet reaction propulsion for the propeller? Or hydraulic plumbing for cables in the primary flight controls? Most significant advances in the science and art of flight have resulted from applying new concepts to circumvent stalemated designs. It is time for us to reappraise the take-off and landing methods now being used on high-performance airplanes.

In order to operate from even well prepared runways, the conventional take-off airplane is equipped with an amazing array of mechanical, hydraulic, electrical, and pneumatic devices. Besides the masterfully designed modern landing gear, the high-performance airplane now incorporates flaps, slats, and—more recently—boundary-layer control. Wing loadings which are lower than desirable for good high-speed performance are also used to improve further the take-off and landing characteristics. However, these efforts at best can only retard the somewhat steady increase of take-off and landing speeds.

Associated with the higher ground speed problem is the matter of increasing runway length requirements. Landing at higher speeds means a greater amount of kinetic energy in the airplane at touchdown, and braking capacity is quite limited within the shrinking confines of the small landing wheels. To offset the braking deficiency, a drag chute is often deployed at touchdown to absorb much of the kinetic energy in drag; but, again, this is a device which is carried throughout the airplane's flight when its only use is in landing.

Take-off and landing speeds are closely linked with the stalling speed of an aircraft.[1] To obtain a 75- to 100-lb. per sq.ft. wing-loading which is desirable for high-speed flight, it becomes necessary to accept extremely high stall speeds. In fact, considering a standard 20 per cent margin above stall for the landing speed, it may be necessary for a high-performance airplane to touch down at 180 knots. True, such a speed may be only a fraction of an airplane's top speed, but the operating environment is far less forgiving of a mistake.

Although take-off distances are noted to be relatively short, landing distances are not. In general, the take-off distance is becoming less of a problem with the modern trend to higher thrust/weight ratios. However, in landing, the high thrust is not of any value. Efficient thrust reversers and boundary-layer control may some day improve this picture, although, here again, there will be more dead weight to carry in the air. As it stands today, runways in the 10,000-ft. class are required for most jet operations. This poses no small problem in finding suitable real estate and maintaining the smooth, hard surface required of the modern runway.

Aircraft carrier operation has required even more careful attention to minimizing take-off and landing speeds. Heavier catapults for launching and arresting systems of increased capacity are two of the ship's answers to the higher airplane speeds.

With the current trend to higher thrust/weight ratios to increase maximum speeds, we are gaining the capability to improve on the present conventional take-off and landing methods. Eventual application of VTOL principles will free the high-performance airplane from long runways, from high speeds in the presence of the unyielding earth, and from the important performance compromise of a low wing-loading. Design trends are going in this direction, and evolution is being materially hastened by present research work.

The thrust loading of an airplane determines to a large extent the take-off distance, rate-of-climb, maneuverability, combat ceiling, and maximum speeds.

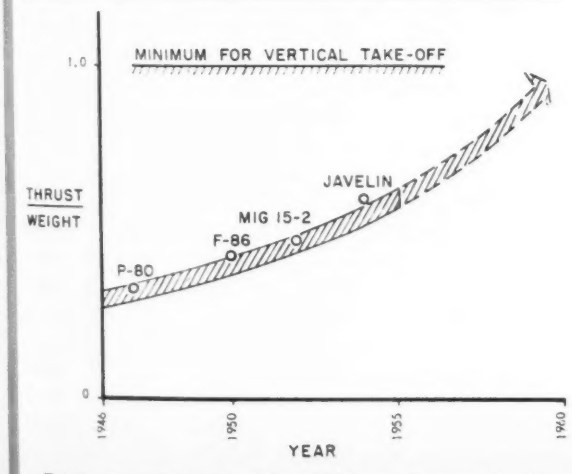



FIG. 1. Static thrust loadings of high-performance aircraft.

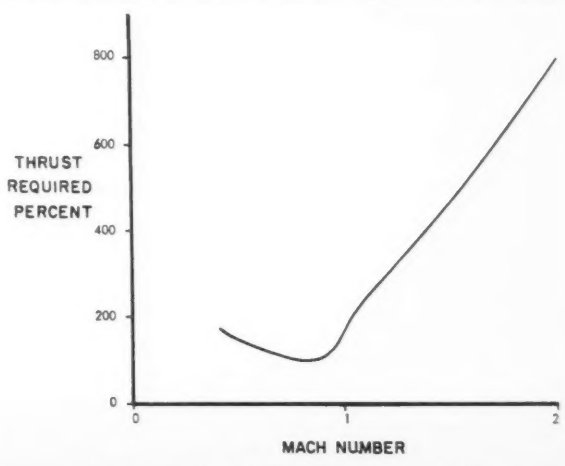



FIG. 2. Typical airplane drag characteristics.

Today's thrust demands are primarily resulting from the demand for higher speeds and increased maneuverability at high altitudes.

Thrust loadings have been steadily increasing with time, as shown in Fig. 1.[2] We are already near a thrust/weight ratio of 0.6 in current high-performance aircraft. Additional refinement of the jet engines powering these and other aircraft will continue to push the ratio even higher.

We have needed these higher thrust/weight ratios in order to obtain higher speeds. The thrust required to produce a given speed is a function of the airplane drag characteristics and altitude. A typical variation of airplane drag (and hence thrust required) is shown in Fig. 2. We see here that the thrust required at Mach 2 may be twice that at Mach 1.4. Consequently, our thrust/weight ratio would have to go up by a factor of two. Since the air loads at Mach 2 will be substantially greater than those at Mach 1.4, it is not likely that airplane weight will be materially reduced for the higher speeds. Unless some unconventional means such as rockets or ram-jets are used to produce this higher thrust, we can expect that the sea-level static thrust will increase in proportion to the high-speed thrust. It becomes obvious then that the resultant take-off thrust/weight ratio may exceed one, and we will have the capability for VTOL. If we have an installed thrust which is high enough to produce Mach 2 flight, we would be wise to use it for other phases of flight—namely, take-off and landing. The thrust required for vertical ascent must necessarily exceed the weight of the airplane with some small margin left over to cover installation losses, maneuvering controls thrust loss, and a small margin for acceleration. Since each of these items is intimately connected with the engine/air frame combination, no specific values are assignable to them. However, we can get an idea of what may be usable from experience gained in some vertical rocket firings.[3] As an example, the Viking 11 on its record-breaking flight to 158 miles altitude took off with a thrust/weight ratio of 1.425. Since this rocket was fully controlled during take-off, it may be assumed to be somewhat

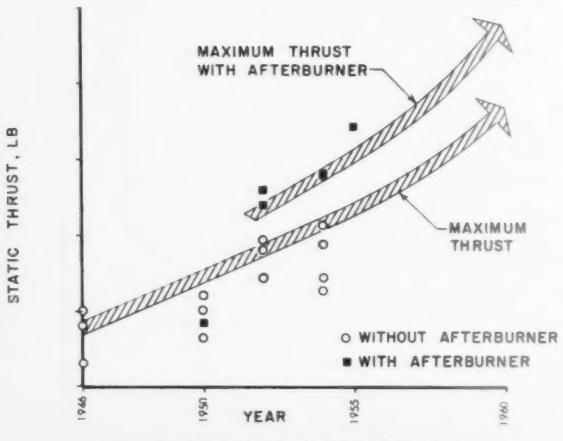



FIG 3. Turbojet engine thrust trends.

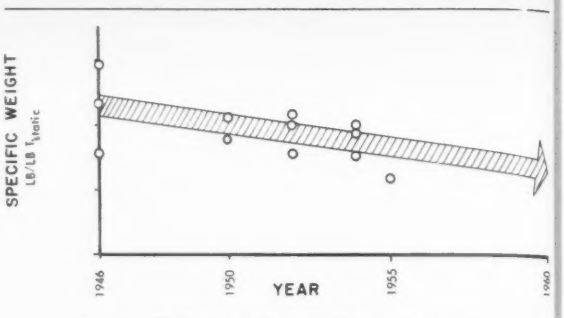



FIG. 4. Turbojet engine specific weight trends.

representative of a vertical take-off vehicle. But let us not generalize too far on this and simply state that the *net* thrust available under any take-off condition must exceed the gross weight.

The advent of the gas-turbine power plant has provided the stepping stone necessary to the development of a VTOL airplane. High power output at low engine weight has made possible static thrust/weight ratios greater than one required for a vertical take-off. It was natural that the first VTOL airplane (Convair XFY-1) should combine the high power, lightweight gas-turbine engine with the comparatively efficient contrarotating propellers. The Convair XFY-1 has already demonstrated its ability to hover and fly through transition into level flight and return to a controlled vertical landing. However, the design high speed of the propeller-driven aircraft is subsonic, so its tactical usefulness is limited. A successful VTOL airplane must have a performance potential equal to that of its competition. Thus, the turbojet engine appears as a logical choice for a high-performance VTOL airplane.

Reviewing the turbojet engine development trends in Fig. 3, we see that engine thrusts are increasing rapidly.[4] This undoubtedly will level off in some later year because of factors which, at present, are not of significance. One such factor may be the high ram-air temperature encountered at extremely high speeds. Once the thrust plateau of turbojets is attained, the emphasis on power-plant development will, in all probability, shift to ram-jets or rockets for propulsion at higher speeds, and turbojet development will then be directed with considerable blessing toward improving efficiency.

That we will soon have engines capable of powering VTOL airplanes is an obvious conclusion. At the date of this writing, the de Havilland Gyron has passed its 150-hour test at a thrust of 15,000 lbs. without an afterburner. Equipped with an afterburner, this same engine today should produce a thrust of 20,000 lbs. or more. Such a thrust level is certainly nearing adequacy for VTOL application. Designs requiring an installed thrust greater than that provided by a single engine can resort to multiple-engined installations, as already done by Rolls-Royce, Ltd., and Bell Aircraft Corporation in their test vehicles.

Use of an afterburner for high-speed flight is generally accepted as a necessity. On a unit frontal area basis, the afterburner-equipped turbojet engine de-

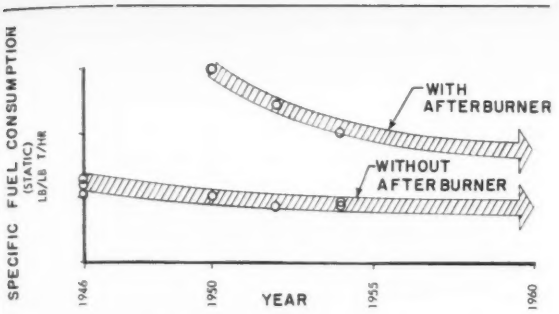



FIG. 5. Turbojet engine fuel consumption trends.

velops 30–40 per cent more thrust at static conditions and up to 100 per cent more thrust at supersonic speeds than its unaugmented counterpart. Because of this better thrust per unit frontal area, the afterburner-equipped engine allows easier packaging in the high fineness ratio fuselages needed for supersonic flight.

In meeting the required thrust/weight ratio, the problem will be one of not only getting adequate thrust but also simultaneously realizing a minimum gross weight. Since the power-plant weight is such a large portion of the airplane weight and since turbojet plus afterburner fuel consumption is notoriously high, the engine specific weight and specific fuel consumption are also extremely important design parameters. Both of these are improving with time (Figs. 4 and 5).[4] It is of interest to note in this connection that the Bristol Orpheus engine has reportedly attained a static thrust/weight ratio of 4.4 and that the de Havilland Gyron Junior is expected to approach 7.

It is perhaps dangerous to attempt to predict futures, especially in someone else's field, but it must be done here to substantiate certain obvious trends in aircraft development. The justification for these engine development predictions lies in the conservative assumption of a continuous improvement of present engine designs. To the same extent that some readers will consider these extrapolations rash, we would be equally conservative to think that engine development will continue without significant changes and improvements in engine design concepts as typified by the by-pass engine of Rolls-Royce.

Following closely behind power-plant development as a necessary adjunct to VTOL airplane development are the advances being made in the knowledge of the aerodynamics of flight. To discuss this, it is convenient to divide the flight into three different regimes. If the airplane is supported in the air by the engine thrust alone, it is said to be in hovering flight, and aerodynamic forces are negligible and inertia forces dominant. If the airplane is moving in a "normal" fashion with all of the lift coming from the wings, it is said to be in conventional flight, and aerodynamic forces are dominant. During the change from hovering to conventional flight and vice versa, the lift is shared by the wings and the engine thrust, and the airplane may be said to be in transition flight. Inertia and aerodynamic forces are both important in transition.

Considerable work is being done to develop airplane shapes which are capable of flying at angles of attack from 0° to 90°. It is somewhat of a paradox that, after years of training our pilots to keep their landing approach speeds above the stall speed, we will soon ask them to fly below the stalling speed of the airplane before they land. Certainly to do this, the shape concept of the airplane must have changed, and it did as indicated by the low aspect ratio delta-wing Convair XFY-1 airplane.

The low aspect ratio wing is a product of this age of speed. At one time the aerodynamicist shuddered at the thought of a wing whose aspect ratio was less than 7 or 8, but that was before compressibility was a problem. Now, with speeds measured by Mach Number, we have resorted to the low aspect ratio wing for speed, although at the cost of overall efficiency. That the low aspect ratio wing is also usable for VTOL design purposes is truly a stroke of good fortune.

The high aspect ratio wing, which has been in favor in the past because of its low induced drag, generally has an abrupt stall. This has been tolerated because warning in the form of prestall buffet was usually noticed and aileron control could be maintained to prevent spins. Safe flight became the rule, provided the pilot kept his air speed up and practiced his stalls at altitude.

The high aspect ratio unswept wing tends to stall as a unit. Modifications to the wing such as camber and

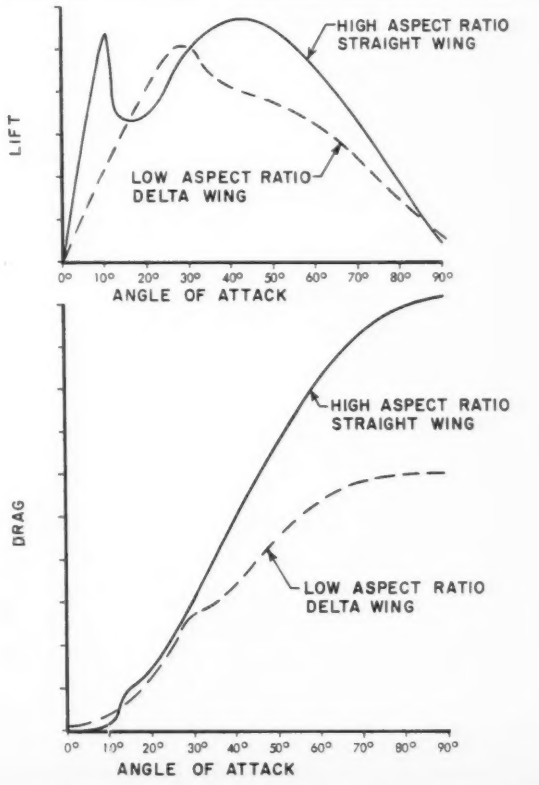

LIFT
HIGH ASPECT RATIO STRAIGHT WING
LOW ASPECT RATIO DELTA WING
0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
ANGLE OF ATTACK
DRAG
HIGH ASPECT RATIO STRAIGHT WING
LOW ASPECT RATIO DELTA WING
0° 10° 20° 30° 40° 50° 60° 70° 80° 90°
ANGLE OF ATTACK

FIG. 6. Longitudinal aerodynamic characteristics in transition.

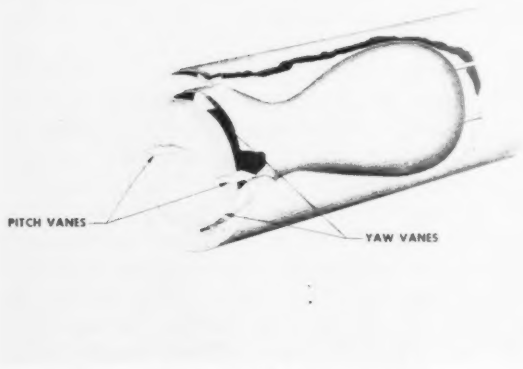



FIG. 7. V-2 missile jet vane control.

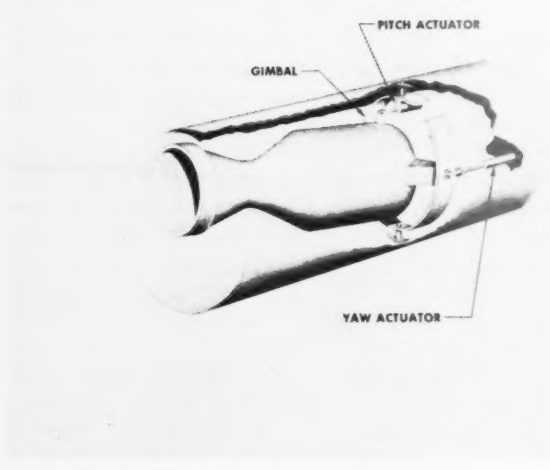



FIG. 8. Viking missile gimbaled rocket motor.

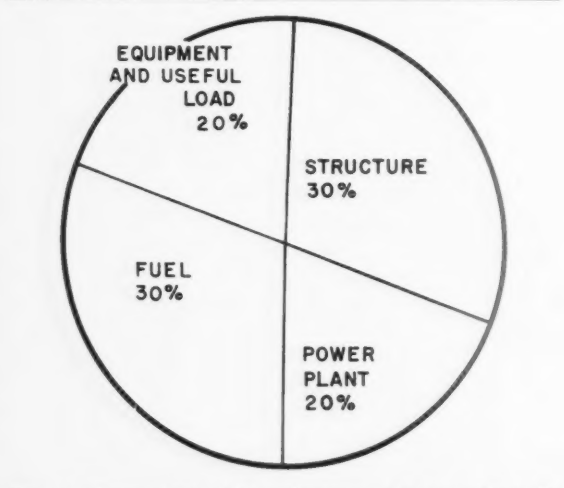



FIG. 9. Conventional high-performance airplane weight distribution.

twist are directed principally at preventing premature tip stall and loss of aileron control. The low aspect ratio tapered wing, on the other hand, does not stall as a unit. Stalling of the low aspect ratio delta wing presents an interesting phenomenon.[5] High-pressure air from the underside of the wing flows forward around each swept leading edge and over the top surface to form a pair of leading-edge vortices. At low angles of attack, the vortices lie along the leading edge, but at high angles they sweep back over the upper surface. These vortex flows tend to sweep the air from the inner wing outboard and thus prevent a sharp stall pattern.

The variations of lift and drag throughout the transition range are illustrated in Fig. 6 for typical high and low aspect ratio wings.[6,7] Note the more gradual change in the lift of the low aspect ratio wing throughout the whole range. This, coupled with good longitudinal stability and adequate aerodynamic control, will ensure that the airplane can safely be flown above the angle of maximum lift.

If the airplane in transition has to be supported jointly by aerodynamic lift and engine thrust, then a balance of forces must be obtained. Since aerodynamic forces are uniquely determined by the angle of attack and by air speed, final "balancing" of the airplane will have to be accomplished by varying the thrust.

Control of the jet VTOL airplane will be accomplished through a combination of aerodynamic and jet reaction means. Since there is no propeller slipstream over the control surfaces as in the Convair VTOL airplane, the aerodynamic controls alone are inadequate at low speeds. Supplementary control must then be provided which can be done by using various forms of jet reaction moments. One of the earliest well-known forms of jet reaction controls was the jet vane control of the German V-2 missile. Fig. 7 shows these jet vanes in the rocket nozzle of the V-2 missile. Deflecting pairs of opposite vanes produced either a pitching or a yawing moment, while deflecting pairs of opposite vanes in a differential manner produced a rolling moment.

Another means of operating on the main jet exhaust to produce a control moment is to rotate the thrust line. A typical example of this technique is the Viking missile gimbal rocket nozzle shown in Fig. 8.

A third control method using auxiliary jets displaced from the center of gravity was employed by the Rolls-Royce test vehicle. The auxiliary jet can be supplied with a working fluid from the primary power source or from an auxiliary power source. Control is achieved by differential operation of pairs of opposite jets which tilt the aircraft and hence the thrust line.

Equally as important as high static thrust for VTOL operations will be the overall airplane weight. Careful consideration of weight in the design of any airplane can result in a major improvement in its flight performance. We have seen in past aerial warfare history some examples of lightweight airplane designs whose altitude and maneuvering performance have exceeded that of the comparable opposing aircraft. The Japanese Zero and Russian MIG-15 fighters became formidable

opponents largely because of their lightweight design. In current aircraft developments, the Douglas A4D is reportedly enjoying brilliant air-borne performance largely because of a clean, lightweight design. The VTOL airplane will have to adopt and even extend this same philosophy of efficient lightweight design to be successful.

The first goal in a VTOL development is a take-off thrust/weight ratio that is in excess of 1.0. Weight can be equally as important as thrust in attaining this figure, and it must be given careful consideration. Fig. 9 shows the weight distribution in a modern, conventionally designed high-performance aircraft.[5] Power plant plus fuel is seen to total approximately one half of the conventional airplane's weight.

The weight distribution for a comparable VTOL lightweight airplane would approach that shown in Fig. 10. As would be expected, engine weight will become a larger percentage of the gross weight. To compensate for this, weight reductions must then be realized in other areas. Although some weight may possibly be taken from the fuel load and useful load, most of it must be pared from the equipment, powerplant installation and accessories, and, finally, the structure. The most obvious weight reduction comes from the elimination of the landing gear, flaps, slats, and all the other devices required for conventional runway operation. Although some weight will have to be put back in to permit vertical landings, it will be small compared with the 6 to 8 per cent of the gross weight contained in the foregoing items.

The Douglas Aircraft Company has proved that many essential aircraft components can be radically lightened by weight-conscious designing.[8] Taking advantage of such lighter weight equipment and components (and also carefully eliminating the unnecessary one) further reduces the weight.

Finally, the structural weight itself will have to be decreased. Part of this decrease will be a natural result of reducing the amount and weight of the equipment to be carried in it. In order to realize the remaining structural weight decrease, certain design philosophies will have to be followed:

(1) First is the use of a unitized structure. One-piece wing and one-piece fuselage are examples of unitized design.

(2) The remaining concentrated load carrying members must be made to serve a dual purpose wherever possible. As an example, the heavy engine mount fittings may also support armament or airbrakes.

(3) Maximum use of high strength/weight ratio materials must be made. The expanded use of titanium or stainless steel in areas subject to maximum aerodynamic heating or engine heat radiation may result in a lighter weight than possible when using reduced-strength aluminum.

(4) The fourth essential principle will be to design close to the margin.

Making maximum use of the best lightweight design concepts, we will be able to meet the weight picture of Fig. 10. It is a marked departure from the conventional airplane weight distribution and will require extensive creative designing.

To be successful today, an airplane must also have a built-in growth potential. High-performance aircraft have price tags in excess of one million dollars. We cannot expect the customer to buy such a costly product and then not assure him of its long and useful life. It is also true that the aircraft industry does not have the capacity to develop and produce an infinite variety of these complex machines requiring extensive engineering and development. Therefore, the trend is toward good basic designs which have an inherent growth potential. Past examples of this practice are the Lockheed F-80, Douglas AD, North American F-86, and Grumman F9F series.

Growth potential is simply the capacity for increased performance, multiple duty versions, or greater load carrying ability through in-production improvements of a basic air frame/engine combination. Since the VTOL airplane will be inherently clean, light, and highly powered, it will not be lacking in the basic performance requirements. The capability of performing tasks other than that for which the airplane was originally designed is mostly a matter of vision and development. There is no reason to believe that the VTOL concept will unduly limit the versatility of the airplane. In this regard, one fact is certain: Due to its vertical take-off and landing capabilities, it will be applicable to tasks completely outside the scope of its runway-bound counterpart.

Increasing the load carrying capacity of a VTOL airplane will follow a somewhat different criterion than used for a conventional airplane. Instead of relying on lengthening runways or more powerful catapults to attain a higher take-off speed, the thrust level will have to be directly increased. Auxiliary thrust for this purpose may be provided by rocket motors or secondary turbojet engines. The amount of auxiliary thrust provided must necessarily exceed the weight added, in-

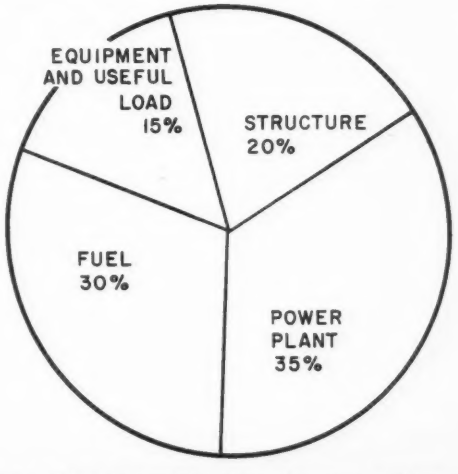



FIG. 10. VTOL lightweight high-performance airplane weight distribution.

cluding the weight of the auxiliary thrust motors.

This type of assisted overload take-off must not be confused with the more spectacular zero-length take-offs of current long-range, winged missiles. The pilot of the VTOL airplane will retain full control during take-off, and his acceleration will remain relatively low. Further, after the excess load has been expended, the VTOL airplane will be capable of making its normal vertical landing without assist.

Another growth potential which the VTOL airplane will automatically gain is the thrust uprating resulting from engine design refinements. Few data are available on this, but judging from improvements on the Pratt & Whitney J-48 engine, a thrust increase of up to 3 per cent per year can be realized. On the high thrust engines considered here, this becomes a sizable amount.

What form the VTOL airplane will eventually take is not evident at this stage. The horizontal fuselage concept of Bell's provides a more conventional environment to the pilot during the take-off and landing. However, the problem of rotating the turbojet thrust line through 90° may not be so simple. Should the choice lie with the tail-sitter configuration similar to the Convair XFY-1, it becomes a matter of pilot training to adapt his reflexes to suit the semireclining seat. There will be low-speed stability and control problems inherent in each type of VTOL aircraft. Many have already been solved through joint research work by Government and industry groups, and the rest can certainly be solved in a similar manner.

Research vehicles are today exploring the realms of hovering and transition flying. The next step, and it is the all-important one, is the integration of VTOL principles into a useful air frame. From then on, we may expect a rapid development of the VTOL airplane much like that the helicopter experienced.

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## Some Considerations of the STOL Airplane


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Fairchild Aircraft Division


EMPHASIS on reduced take-off and landing distances for all types of military aircraft has been accentuated with the advent of nuclear weapons. Military or industrial centers, stricken by nuclear weapons, will require immediate transportation for the evacuation of casualties, decontamination, resupply, and reconstruction. Such air support can be effected only around the blast perimeters, using unprepared strips or open fields. Any future major conflict, in all probability, will be global, and it is apparent that a "Maginot Line" of air fields throughout the world is economically unrealistic. World War II established the runway—whether on land or afloat—as a prime target. Dispersion of both military and industrial centers will be mandatory, and runways or airfields an invitation to attack. There is also the peacetime application of short take-off and landing characteristics in the possible substitution of short runways for railroad sidings in industrial areas and in the reduction of warehouses and inventories with the ability for direct supply. In the pursuit of higher Mach Numbers for our fighters and bombers, we have, without question, willingly paid—in dollars, structural complications, and increases in weight and size—to achieve this goal. To obtain the lower speeds of STOL and VTOL aircraft characteristics, we will have to pay similar penalties.

STOL, short take-off and landing, by the modern definition, is not limited to this characteristic alone but has two parts: (1) take-off and landing distance of under 500 ft. over a 50-ft. obstacle and (2) a speed ratio of approximately 10 or higher. It is the second portion that precludes the rather simple solution of adding wing area and dictates the use of added power, probably in a novel manner, not only in take-off but also in landing. This power can come either from the basic power plants or from auxiliary sources—or from both.

Reviewing the background of low-speed flight, we find that the biplane era has some excellent contributions to offer for our current STOL designs. The Curtiss Tanager with its then optimum slat and flap application came into being in 1929. One of the earliest and best STOL design attempts was the Crouch-Bolas biplane, flown in 1934. With the relatively large diameter propellers and biplane configuration, this airplane exploited a maximum utilization of slipstream effect or, as we will refer to it later, "the vectored slipstream principle" (VSP). A more recent and probably better known STOL airplane was the Vought V-173


* Chief Engineer.

Pancake, designed by Charles Zimmerman and flown in 1942. Also in the early 1940's the German Arado 232 made its appearance, incorporating one of the first successful experimental applications of boundary-layer control. With the revitalization of the fixed-wing, low-speed concept, we find today two designs in this category—the French Breguet 940 and, in this country, the Fairchild M-232. The latter is a STOL aircraft based on the use of the vectored slipstream principle. This project is currently undergoing engine and transmission ground tests.

Other approaches are being considered to obtain lower take-off and landing distances in the conversion of existing aircraft, such as the new Fairchild Flying Boxcar. Here a boundary-layer control system is applied to the flaps, ailerons, elevator, and both sides of the rudder surfaces (required for one-engine-out performance). Note BLC application for one engine out on one aileron and rudders (Fig. 1). The system utilizes high-speed blowing and is activated by direct mechanical linkage between the surfaces and the BLC valving. The take-off and landing distances can be reduced, from an already low value, by an additional 25 per cent. The controllable minimum flight speed of 45 knots is possible up to a gross weight of 54,000 lbs. Fig. 2 is a comparison of the increase in surface areas required to obtain the same take-off and landing distances. A 50 per cent increase in all surface areas plus a 5-ft. fuselage extension is necessary to achieve comparable low-speed performance. This, of course, does not account for the drag increase in cruise, the additional fuel requirements, lower cruise speed, etc. In effect, by the flick of a switch, you can obtain the larger wing area needed for landing and take-off or the lower wing area needed for cruise.

Let us quickly review one of the best known lift devices—boundary-layer control (Fig. 3). The Arado low-velocity, combined suction and blowing system, although one of the first installations, shows strong

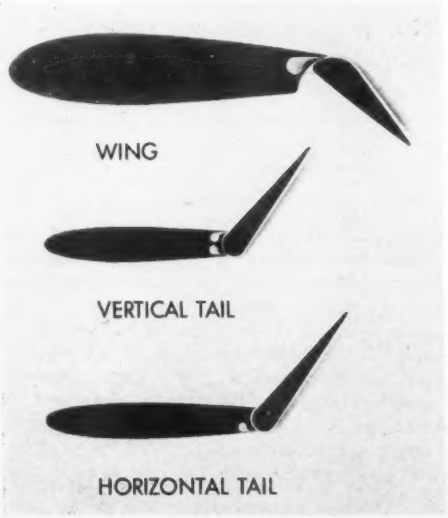


FIG. 1. M-231 BLC system.

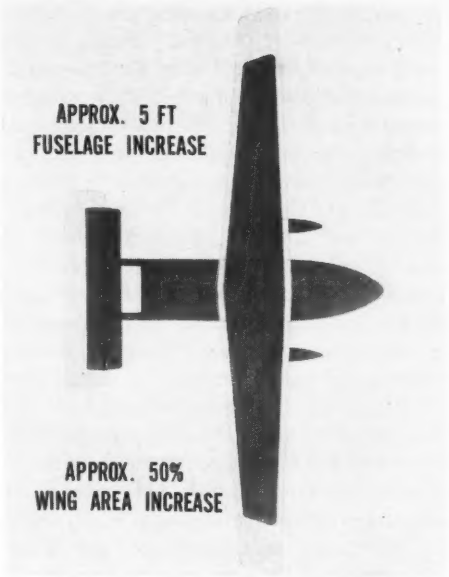


FIG. 2. M-231 BLC area comparison.

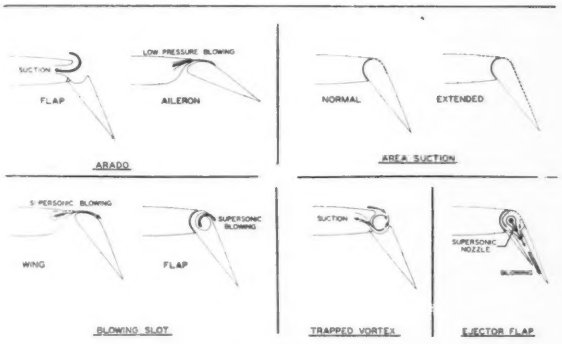


FIG. 3. BLC flap types.

future potential. The high-speed blowing system is the simplest and is presently in production on turbojet-engine aircraft. Two other BLC methods still in the development phase are shown. Other, more advanced, types of BLC are in the research phase.

The vectored slipstream principle is familiar to most of us as power-on effect (Fig. 4). The use of the new nomenclature is justified in consideration of refinement necessary to optimize low-speed thrust, the location of the propeller plane, centerline, and angle in respect to the wing and flaps. Consideration of each variable is necessary to obtain maximum lift effects. Here, the propeller was separated from the wing for ease of relocation during tests. There are improvements possible in propellers for VSP. These include the development of larger diameters for given power levels, higher thrusts at low speeds, and possible articulation. This propeller development will set up a chain reaction of changes in propeller, hub design, and engine gear ratios. Structural loads due to larger variations of inflow angles will be a major consideration. Greater benefits from vectored slipstream can be derived when it is used in com-

bination with large chord flaps and boundary-layer control.

Various types of possible propeller interconnect are depicted schematically in Fig. 5. These require detail analysis as to weight, cost, efficiency, maintenance, and serviceability. They are applicable to designs in which the main power plants are used for take-off and landing to attain STOL characteristics. They are intended to minimize the effect of an engine failure, with its associated asymmetric lift loss and deterioration of control responses. The probability of engine failure now must be compared with failure of propellers and their controls plus failure of the interconnects. The stability and control problems should by no means be minimized for STOL aircraft designs. With the air deflected downward from the wing, the conventional tail and its location are bound to require drastic revisions.

In our concentration on high-lift devices we tend to overlook the practical requirements of STOL characteristics. With the low take-off and landing distances we will have capabilities to operate from small open fields, if not from potato patches, and we will have to provide for an undercarriage which will be suitable for these surfaces, *rain* or shine. There will be a new set of gear requirements for STOL aircraft.

The fixed-wing aircraft, with conventional attitudes, STOL or VTOL, have a major advantage in their ability to substitute additional pay load for take-off distance and still maintain a high cruise speed (Fig. 6).

Let us summarize the development of devices contributing to STOL aircraft designs and the objectives and methods for obtaining STOL characteristics. We want:

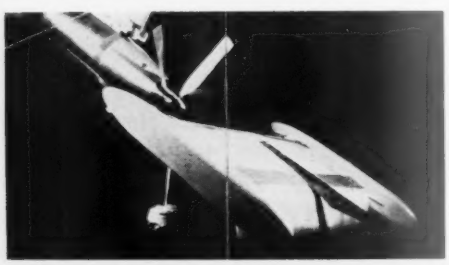

FIG. 4. Vectored slipstream principle. Fairchild model under low-speed and static test conditions at M.I.T.

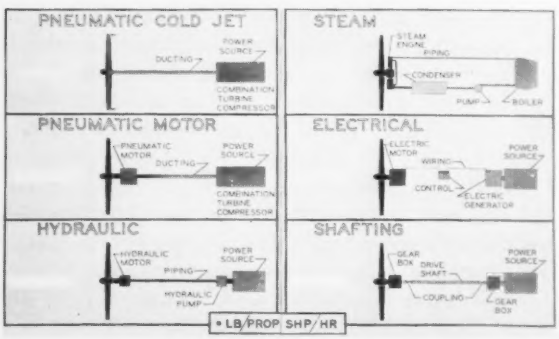


FIG. 5. Propeller drives.

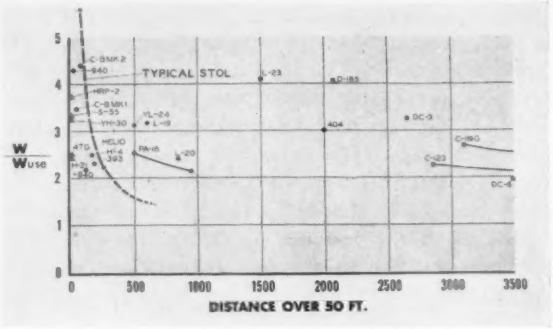


FIG. 6. Comparison of contemporary and VTOL aircraft.

(1) To minimize wing and tail areas, reduce drag, and maintain a wide speed range.

(2) To make up for wing area of the low speeds by utilizing optimum high-lift devices: (a) flaps with boundary-layer control and (b) application of the vectored slipstream principle in conjunction with (a).

(3) To produce vertical force directly from power plants during landing by (a) variable thrust incidence and (b) vectored slipstream with auxiliary drag devices.

(4) To consider the shrouded propeller with its improved low-speed thrust of approximately 25 per cent.

(5) To augment our normal power with other types of power plant such as turbojets. In such cases, the Jet Wing, or Jet Induced Lift principle, jet exhaust deflection, or the tilting of the jet engine may well be applied.

(6) To solve the stability and control problems.

(7) To design suitable rough field gear for STOL aircraft.

## Remarks on the Efficiency of STOL Aircraft

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SUMMARY

Efficiencies of STOL aircraft are discussed on the basis of a parametric study of twelve utility-type airplanes equipped with lift augmenting devices by blowing air over deflected flaps during take-off.

Results indicate that the load carrying and structural efficiencies decrease as the take-off ground run is shortened. On the other hand, the speed ratio, $V_{max}/V_{to}$, increases as the ground run becomes shorter.

Presented also is a concept of a "universal" boundary-layer control system operating through the whole range of speeds, increasing lift at low speeds and decreasing drag at high speeds.

* Director of Research.

TABLE 1
Scope of Studied Configurations

| TYPE | PASS. & CREW | RANGE IN MILES | $S_g$ IN FEET | $W_G$ IN LBS. | $S_W$ IN Sq Ft. | HP RATED | $C_{L_{MAX}}$ $\delta_F$=45° | HP $BLC_{TO}$ |
|---|---|---|---|---|---|---|---|---|
| 1 | 6 | 700 | 600 | 6300 | 240 | 790 | 2.67 | 0 |
| 2 | 6 | 700 | 400 | 6700 | 250 | 790 | 5.04 | 60 |
| 3 | 6 | 700 | 200 | 6900 | 260 | 790 | 7.21 | 65 |
| 4 | 6 | 1000 | 600 | 7300 | 270 | 790 | 2.67 | 0 |
| 5 | 6 | 1000 | 400 | 7750 | 290 | 790 | 5.04 | 67 |
| 6 | 6 | 1000 | 200 | 7950 | 300 | 790 | 7.21 | 71 |
| 7 | 8 | 700 | 600 | 8250 | 310 | 790 | 2.67 | 0 |
| 8 | 8 | 700 | 400 | 7650 | 330 | 790 | 5.04 | 76 |
| 9 | 8 | 700 | 200 | 8900 | 340 | 790 | 7.21 | 84 |
| 10 | 8 | 1000 | 600 | 9500 | 360 | 1160 | 2.67 | 0 |
| 11 | 8 | 1000 | 400 | 10100 | 380 | 1160 | 5.04 | 88 |
| 12 | 8 | 1000 | 200 | 10260 | 390 | 1160 | 7.21 | 96 |

## INTRODUCTION

CESSNA AIRCRAFT COMPANY recently completed a general feasibility study of STOL tactical aircraft. The study was initiated and supported by the Army Transportation Corps and administered by the Air Research and Development Command. Twelve variations of six- and eight-seat utility, command-type aircraft were studied. The results are presented in terms of design parameters, on the basis of which the optimum configurations for each type of aircraft were recommended. The following remarks on efficiencies of STOL aircraft are limited to a group of twin-engined aircraft of conventional configurations with and without forced circulation by blowing air over deflected flaps.

## EFFICIENCY OF THE STUDIED AIRCRAFT

In trying to define efficiency of an aircraft or a group of aircraft for comparative purposes, one arrives at the conclusion that there is no single criterion that can separate efficient aircraft from the less efficient. The reason for this is that there are several kinds of efficiencies by which aircraft can be judged. To mention but a few of the most important:

(1) The propulsive efficiency ($\eta_p/sfc$) depends upon the engine and propeller characteristics and varies with speed, altitude, and power required in flight.

(2) Aerodynamic efficiency ($L/D$) depends upon the aerodynamic cleanness, aspect ratio of the wing, and the angle of attack at which the aircraft flies.

(3) Load carrying efficiency ($W_u \times V_{cr}$) or the useful load carried at a given cruising speed.

(4) Range efficiency ($R/W_f$) miles flown per pound of fuel used.

(5) Take-off and landing distance depends upon the thrust to weight ratio, maximum lift coefficient, and wing loading.

(6) Structural efficiency ($W_g/W_e$), the ratio of the gross weight to the empty weight.

(7) Speed ratio, the ratio of the maximum speed to the minimum speed.

It is interesting to note that, notwithstanding the tremendous progress in aviation during the last 25 years, the numerical values of speed ratio have fluctuated between 3.5 and 4.5. In other words, every increase in top speed of aircraft brought a corresponding increase in minimum speed, requiring in some cases miles of paved runways for take-off and landing.

The above-listed efficiencies were computed for the twelve types of aircraft comprising the parametric study, and the results are presented in the following graphs. Since performance near the ground is of paramount importance in this study, the efficiency parameters are plotted against the ground run at take-off.

Table 1 presents the design characteristics of the airplanes and the scope of the study. All twelve airplanes are twin-engined, nontiltable tractor propellers, low winged, and of metal construction. Lift augmentation is achieved by an all-blowing system of forced circulation over deflected flaps and drooped ailerons.

The product of the aerodynamic and the propulsive efficiencies

$$(L/D)(\eta_p/sfc) = \frac{R}{375 \ln \{1/[(1 - W_f)/W_g]\}}$$

in terms of range, fuel weight, and gross weight was computed but is not presented here. It was felt that its effect was sufficiently reflected by the load carrying and range efficiencies shown in the following plots.

Fig. 1 shows how range efficiency or fuel economy is related to take-off ground run.

Fig. 2 illustrates the effect of decrease in take-off distance upon the load carrying efficiency or point to point delivery capability of the studied aircraft.

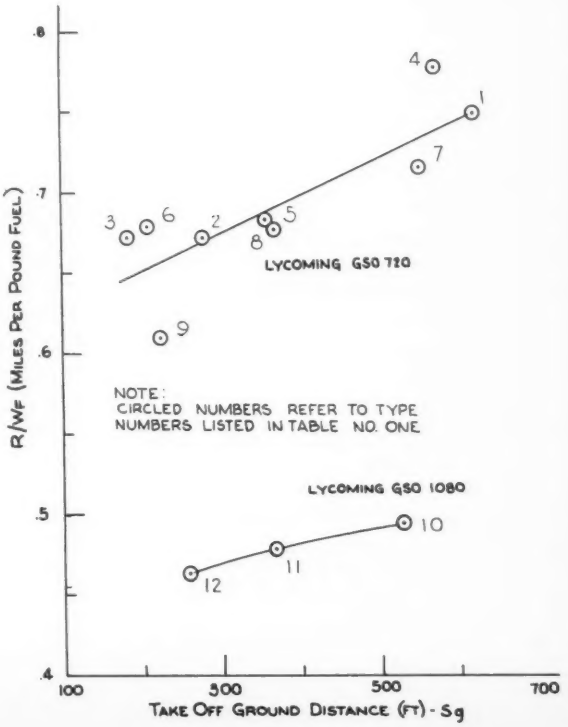


FIG. 1. Range efficiency.

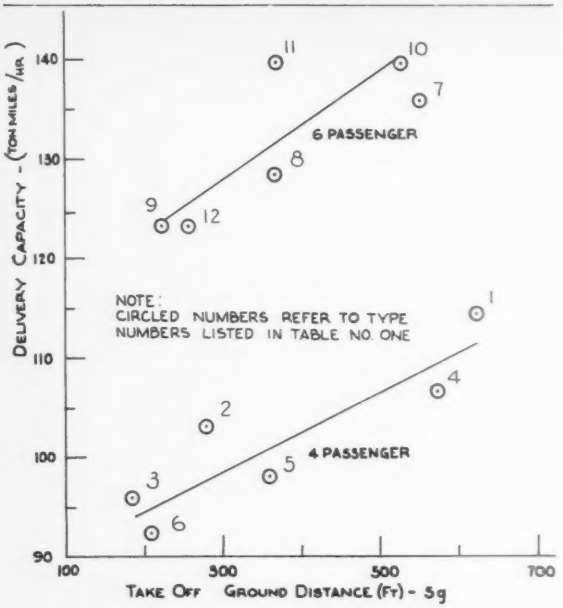


FIG. 2. Load carrying efficiency.

Fig. 3 presents the reduction in structural efficiency as the take-off ground run decreases.

It can be shown that the maximum speed of an aircraft is related to the ground run during take-off by the thrust power loading, thrust at take-off, and optimum $L/D$ (see Appendix).

Fig. 4 presents a grid formed by the graphical solution of the equation

$$V_{max}{}^3/S_g = 11220K_1$$

$$K_1 = \left(\frac{THP_{hs}}{W}\right)\left(\frac{T_{to}}{W}\right)\left(\frac{C_{Lto}}{C_{Dmin}}\right)\left(\frac{1}{\sigma}\right)$$

$K_1$ is a constant for a given airplane. The lines of constant $K_1$ indicate the reduction in maximum speed required in order to achieve shorter ground run for a given airplane. The dotted line is the "line of diminishing returns." It represents locus of points where $\Delta S_g/\Delta V_{max}$ is unity. In other words, airplanes spotted to the left of this line make greater sacrifice in $V_{max}$ in order to achieve short take-off than those located to the right of the line. This line divides roughly VTOL from STOL types of aircraft.

In a similar manner, Fig. 5 presents a grid formed by solution of the equation

$$V_{max}/V_{to} = (K_2/S_g)^{1/2}$$

where $S_g$ is take-off ground run.

$$K_2 = \left(\frac{T_{hs}}{T_{to}}\right)\left(\frac{W}{S_w}\right)\left(\frac{1}{C_{Dmin}}\right)\left(\frac{1}{\rho_0}\right)$$

is a constant for a given airplane. This graph indicates the increase in speed ratio as the ground run becomes shorter. However, as was illustrated on Fig. 4, the increase in speed ratio is achieved, in spite of loss of $V_{max}$, by a greater decrease in $V_{to}$.

## DISCUSSION

The apparent scattering of points representing individual aircraft is explained by abrupt changes in power plants, wing loading, range, and useful load.

The charts are self explanatory and indicate that, in order to achieve a reduction in take-off distance, a compromise must be made in load carrying and structural efficiencies because of the increase in fuel weight and empty weight. It might be argued that these are foregone conclusions and could have been arrived at a priori without constructing these charts. However, the value of the charts lies in their ability to show quantitatively the extent of compromises necessary to obtain the desired performance near the ground. Moreover, the charts were helpful in selecting the optimum airplane by considering aspects other than aerodynamics such as degree of structural complexity, cost and availability of the power plants, BLC, and their respective components.

Efficiencies of STOL aircraft discussed in this analysis are directly affected by the following parameters:

(1) Ability of the lift augmenting devices to produce a desired increment in lift coefficient per minimum weight and power required.

(2) Specific weight, specific fuel consumption, and the ratio of take-off to normal power ratings.

(3) Ability of the propellers to generate high thrust per weight through a wide range of speeds.

This shows for future progress in STOL aircraft the necessity of integrating the lift augmenting unit, the power-plant unit, and the propulsive unit into one efficient aggregate.

In conclusion, I would like to discuss briefly some possibilities and limitations of the STOL aircraft in general. It can be done best by considering the equation of the velocity ratio

$$R_v = \frac{V_{max}}{V_{min}} = \left[\left(\frac{T_{hs}}{W}\right)\left(\frac{C_{Lmax}}{C_{Dmin}}\right)\left(\frac{1}{\sigma}\right)\right]^{1/2} \qquad (1)$$

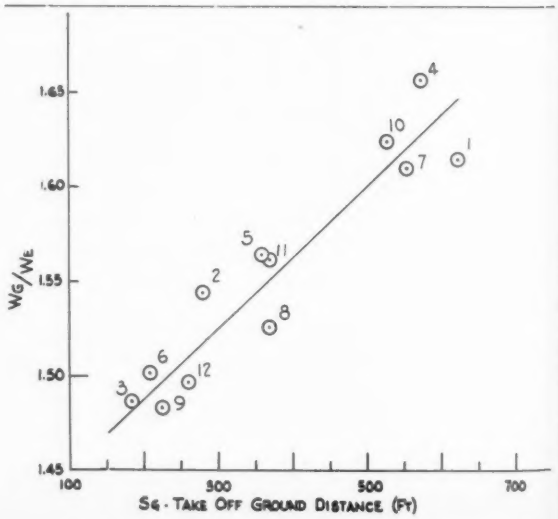


FIG. 3. Structural efficiency. *Note:* Circled numbers refer to type numbers listed in Table 1.

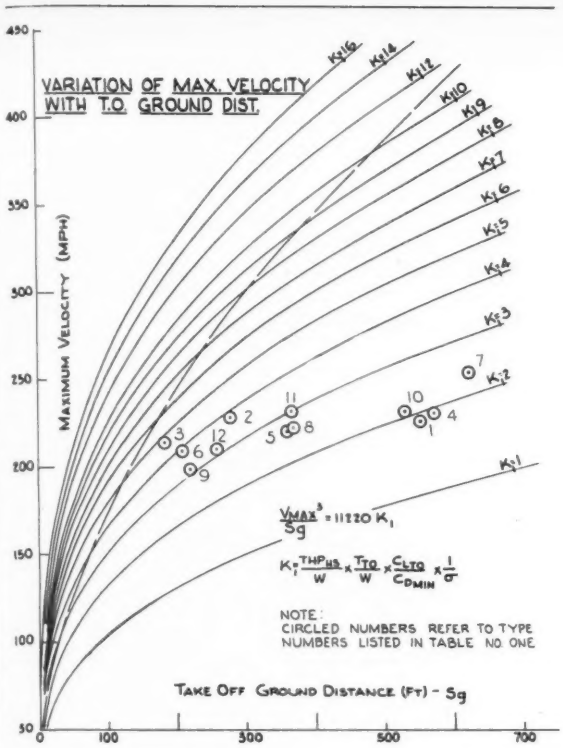
VARIATION OF MAX. VELOCITY WITH T.O. GROUND DIST.
MAXIMUM VELOCITY (MPH)
TAKE OFF GROUND DISTANCE (FT) - Sg
NOTE:
CIRCLED NUMBERS REFER TO TYPE NUMBERS LISTED IN TABLE NO. ONE

FIG. 4.

which relates velocities, thrust loading, and optimum $L/D$.

Considerable increase in speed ratio can be achieved by installing powerful engines and "all-out" lift augmenting devices such as leading-edge slats or slots and double-slotted, trailing-edge flaps designed to produce an effective deflection of the slipstream. This is equivalent to a kind of incipient boundary-layer control utilizing the available dynamic pressure as a means of accelerating air over the wing. However, the results are limited by early separation of airflow over the deflected flaps, high angles of attack necessary to attain the desired lift coefficients, and poor landing performance.

These undesirable features can be alleviated by the installation of a forced circulation boundary-layer control system. Forced circulation delays separation of airflow over highly deflected flaps and generates much greater lift at a reasonable angle of attack.

In this case, Eq. (1) can be written as

$$R_{r_1} = \left[\left(\frac{T_{hs} - t}{W + \Delta w}\right)\left(\frac{C_{Lmax} + \Delta C_L}{C_{Dmin}}\right)\left(\frac{1}{\sigma}\right)\right]^{1/2} \qquad (2)$$

where

$t$ = equivalent thrust required to operate BLC system

$\Delta w$ = weight of the BLC installation

Flight tests* of a liaison-type airplane equipped with a BLC system conducted at Cessna indicate that, in spite of a 10 per cent diversion of power to run the system and an increase in weight, 40 per cent reduction in take-off ground run can be realized.

So far, the reduction of take-off run was considered without regard to high speed, which, paradoxically, is reduced in spite of installation of powerful engines.

If, in addition to short take-off run, a high top speed is required, installation of—shall we say—a "universal" BLC system is proposed. This system will operate throughout the whole range of speed of the aircraft—increasing lift at low speeds and decreasing drag at high speeds.

In this case, Eq. (2) takes the following form:

$$R_{r_2} = \left[\left(\frac{T - t}{W + \Delta w}\right)\left(\frac{C_{Lmax} + \Delta C_L}{C_{Dmin} - \Delta C_D}\right)\left(\frac{1}{\sigma}\right)\right]^{1/2} \qquad (3)$$

or, in terms of pressure and flow coefficients,

$$R_{r_2} = \left(\frac{(C_{Dmin} - C_p C_Q) q_0 S_w}{W + \left(\frac{dw}{dC_Q}\right) C_Q}\right) \times \left(\frac{C_{Lmax} + \left(\frac{dC_L}{dC_Q}\right) C_Q}{C_{Dmin} - \left(\frac{dC_D}{dC_Q}\right) C_Q}\right)\left(\frac{1}{\sigma}\right)^{1/2} \qquad (3a)$$

where

$$C_p = \Delta P / q_0 \qquad \text{and} \qquad C_Q = Q / V_0 S_r$$

NACA and the recent British two-dimensional wind-tunnel tests indicate that 80 per cent reduction in skin friction drag can be attained by suction through porous media. This means up to 20 per cent reduction in total

(*Continued on page 44*)

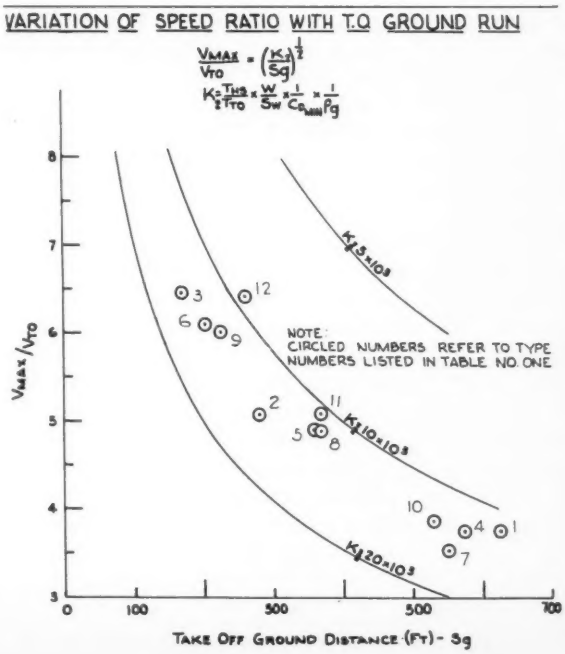
VARIATION OF SPEED RATIO WITH T.O. GROUND RUN
NOTE:
CIRCLED NUMBERS REFER TO TYPE NUMBERS LISTED IN TABLE NO. ONE
TAKE OFF GROUND DISTANCE (FT) - Sg

FIG. 5.

* Sponsored by the Army Transportation Corps and administered by the Office of Naval Research.

*Effectiveness of an NACA-developed system aimed toward elimination of the dreaded fire following crash.*

# Crash Fire Prevention —Research to Flight Test

E. R. Zeek* and I. J. Hammill†
Walter Kidde & Co., Inc.

CRASH FIRE RESEARCH exhaustively conducted by NACA, including full-scale test crashes, not only pinpointed the origins of crash fires but successfully demonstrated the effectiveness of methods of inerting the ignition sources.[1] The Air Force participated in the research by supplying the airplanes for the test crashes and sponsored the development of crash fire prevention equipment by an industrial firm, Walter Kidde & Company, Inc.

The initial step in this development program was two-fold. First, the equipment designed to inert the ignition sources was prepared and then the equipment to inert automatically those sources upon crash impact. The inerting equipment consisted of an exhaust cooling system with its associated tanks, a fuel shutoff valve between carburetor and blower, a $CO_2$ cylinder discharging into the induction system, high-speed fire wall shutoff valves for fuel and oil, and an arrangement for disconnecting the airplane's battery, inerting the generators, and grounding the main bus. The initiating devices consisted of an inertia switch to detect unusual airplane deceleration in a forward direction, engine reaction switches to detect unusual movement of the engine caused by the propeller striking an obstruction, deformation switches in the wings to detect rupture of the wings by poles or wires, and deformation switches on the underside of the fuselage to sense contact of the fuselage with the ground. The initiating devices were connected electrically into four initiating circuits as shown in Fig. 1. A control unit was arranged to receive the signals from each circuit, and whenever two or more signals were received within a 10-sec. interval, it transmitted power to the inerting equipment. Such an arrangement was devised initially to reduce the possibility of inadvertent operation of the system. Note that two deformation switches were mounted in each wing but were connected in different circuits. This was to ensure actuation of the inerting system in the event that a guy wire or some other item severed a wing but did no further damage to the aircraft. Such wing damage would result in fuel spillage and make it desirable immediately to inert the aircraft.

This equipment was developed, built, and installed on one of NACA's C-82's, and a full-scale test crash was conducted in August, 1953. The details of the equipment were reported by Walter Kidde & Company,[2] and details of this test were published by NACA.[3] The airplane was crashed into a barrier at take-off speed with engines at full power. The propeller struck the barrier first, operating the engine reaction switches. The landing gear was wiped off when it struck, closing the inertia switch and completing two circuits, thus actuating the inerting system. The wing fuel tanks were ripped open by poles placed to do just that, spilling the fuel and creating the dangerous fuel mist. The aircraft then skidded to a stop on its belly. Thus, the wing deformation switches and the fuselage deformation switches were actuated, although the inerting had already begun. The inerting system successfully prevented the start of a fire in this crash, where in all

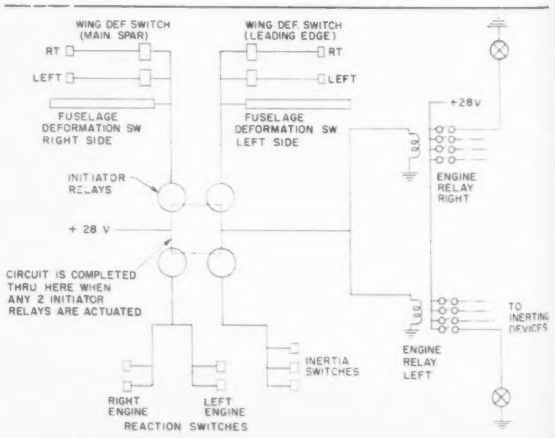


FIG. 1. Initiating system used in C-82 test crash.

Presented at the Flight Safety and Training Session, 24th Annual Meeting, IAS, N.Y., Jan. 23–26, 1956.

* Assistant Vice-President, Engineering and Research.

† Manager, Flight Safety and Special Products Department.

previous crashes under similar conditions without an inerting system a fire had occurred.

Following this successful test, the contract was extended to provide for the continued development of the complete system through the preproduction stage. This required the fabrication of environmentally tested equipment to establish its reliability against inadvertent operation or in-flight failures through a flight-test program. The aircraft selected for the flight test was the C-119F, successor to the C-82. However, this airplane had an engine with a radically different exhaust system (the Wright turbocompound instead of the Pratt and Whitney 2800) which complicated the exhaust cooling system previously developed. In addition, combustion heaters for cabin and deicing heating, instead of heat exchangers in the exhaust system, required the development of a coolant system to render these inert.

The original C-82 cooling method of using spray nozzles trained on the stacks was not entirely satisfactory from a practical viewpoint, being easily susceptible to clogging from external dirt and subject to damage or disarrangement by maintenance personnel. Further, for the cooling spray to be effective, it had to be very close to the hot metal so as not to be blown away by the air stream in the nacelle, and this necessitated a rather large number of nozzles and made complete coverage difficult and unreliable. Because of these deficiencies, a new and better method of exhaust system cooling was developed for the C-119. The hot exhaust system surfaces were covered with fine mesh stainless steel screening. The coolant was distributed along the screened surfaces by tubing in which small holes were drilled at appropriate locations. Coverage by this method proved far superior to the old spray method, and cooling was extremely efficient. The three power recovery turbines in the exhaust system were cooled by internal sprays from specially designed nozzles mounted on the inlet scroll of the turbine nozzle box.

In the C-82, the coolant tanks were mounted to the exhaust collector ring because of the possibility of the collector ring separating as a unit from the engine in a crash. With the C-119 installation, the exhaust stacks and turbines were smaller parts and were more likely to remain attached to the engine; if not, they would separate individually. For the C-119, therefore, the coolant storage tanks were attached directly to the engine. Fig. 2 shows schematically the method of distributing coolant from the tanks to the exhaust stacks and turbines. The coolant solution used has the cooling capacity of water but with salts added to depress the freezing point to $-40°$F. and to increase the generation of inert gaseous atmosphere which protects the nacelle until the cooling is complete.

The $CO_2$ induction inerting system, used in the C-82, was applied unchanged to the C-119 except that engine mounting of the equipment was required. This necessitated the design of a new discharge valve to resist the more severe vibration. A fuel shutoff valve was unnecessary because, in the turbocompound engine, a fuel

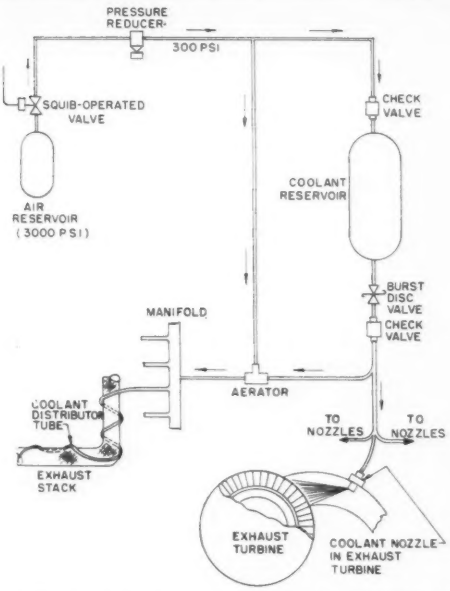


FIG. 2. Diagram of exhaust cooling system, C-119F airplane (Wright R3350 T.C. engine).

valve (the spinner discharge valve) is already installed. It is located in the most desirable location as far as shutting down the engine quickly is concerned, and it was necessary only to build an air-operated closing device which would drive this valve closed when energized from the exhaust cooling system air supply.

The fire wall shutoff valves used in the C-82 test crash were redesigned for the C-119 to withstand the environmental tests. They are essentially gate-type valves, spring-loaded and solenoid-operated to close or open with the spring being rewound by a motor. They are quick-operating valves, closing in approximately 0.04 sec. and opening in twice that time. Closing these valves serves to reduce the amount of combustibles spilled into the nacelle from lines broken as a result of the crash.

The electrical system is inerted, as in the C-82, by disconnecting the battery from the bus, de-energizing the engine-driven generators by opening their field circuits, and de-energizing the main bus by grounding it. This quickly dissipates the residual energy in the rotating and inductive electrical equipment and thus completely inerts all regular power wires throughout the airplane. The crash fire inerting equipment is separately powered from the battery through the control unit, and its lines are de-energized by a delayed action switch in the control unit after the equipment has had sufficient time to function. The components used in inerting the electrical system are standard Air Force approved contactors and switches.

The inerting of the combustion heaters in the C-119 is accomplished by a water-spray system that cools the hot metal of the heater combustion chamber with an internal spray and cools the heat exchanger section with several external sprays. Water without the addition of salts is used as the cooling medium because the cabin

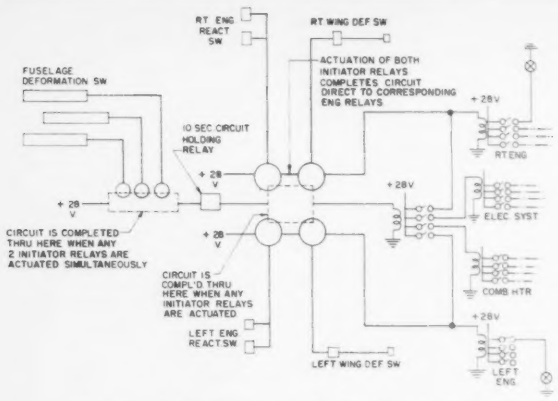
RT. ENG REACT SW.
RT WING DEF SW
FUSELAGE DEFORMATION SW
ACTUATION OF BOTH INITIATOR RELAYS COMPLETES CIRCUIT DIRECT TO CORRESPONDING ENG RELAYS
+28V
10 SEC CIRCUIT HOLDING RELAY
+28 V
RT ENG
+28V
ELEC SYST
CIRCUIT IS COMPLETED THRU HERE WHEN ANY 2 INITIATOR RELAYS ARE ACTUATED SIMULTANEOUSLY
+28 V
CIRCUIT IS COMPL'D THRU HERE WHEN ANY INITIATOR RELAYS ARE ACTUATED
COMB HTR
+28V
LEFT ENG REACT SW
LEFT WING DEF SW
LEFT ENG

FIG. 3. Initiating system for C-119F airplane.

heating ducts would conduct the vapors into the cabin. The fuel, controlled by a solenoid valve, automatically shuts off when the electrical system is de-energized. As a further precaution, the heater fire-extinguishing system is discharged, inerting the space surrounding the heater with carbon dioxide.

An auxiliary power plant is carried in the C-119, and standard operating procedure is to have it in operation during take-off and landing as an emergency power source. Only a portion of the exhaust stack is hot enough to be an ignition source, and it is inerted by lagging it with asbestos tape which prevents combustible vapors from coming in contact with the hot surface. The combustible mixture within the engine is inerted, and the engine is shut down by injecting $CO_2$ into the air intake, using a charge large enough to last until the engine stops rotating. The generator is de-energized by opening its field circuit.

The initiating system devised for the C-82 test crash functioned very well, and it was originally planned to use the identical system for the C-119. In that system, the actuation of any two initiating circuits within a 10-sec. interval inerted the entire airplane. However, the possibility of such a system being inadvertently actuated in flight, with consequent loss of power in all engines, led to doubt as to the advisability of such an arrangement. NACA proposed a system of local inerting confined to areas where damage was sustained until positive ground contact was established. Consultation between NACA, the Air Force, and Kidde resulted in the adoption of this principle and the evolution of the present system. (See Fig. 3.)

In this system, therefore, nacelles are inerted individually and immediately whenever damage is sustained that is severe enough to make it unlikely that power can be drawn from that nacelle. The entire airplane can be inerted only after a combination of initiating devices has been actuated that establishes the fact that some damage has been sustained and that, most important, the fuselage is in contact with the ground.

The crash sensing devices are engine reaction switches mounted on the engine mounts, deformation switches mounted in the wings, and deformation switches mounted on the underside of the fuselage. The inertia switches have been eliminated from the initiating system pending further study. NACA research has determined that some very low decelerations are experienced in many survivable crashes. Setting the inertia switches to operate for such conditions could permit the possibility of inadvertent operation of this circuit in flight where the same low decelerations have been experienced in rough weather.

The engine reaction switch (Fig. 4) consists essentially of a spring-loaded plunger which operates a microswitch when moved from a neutral position. The plunger and switch assembly is mounted on the engine casing near the engine mount, and a bearing plate attached to the engine mount ring holds the plunger in the neutral position. Rotational movement of the engine causes the plunger to slide along the bearing plate, while fore-and-aft movement of the engine causes the plunger to move in and out. Any motion sufficient to cause the engine shock mount to bottom, which is far more than the normal movement even during rough operation, will operate the microswitch. Two of these units are mounted on each engine.

The wing deformation switch (Fig. 5) is similar to the reaction switch in construction, except that a cable is attached to the plunger. The cable is stretched through the wing, under the tension provided by the spring loading. Normal stretching or contraction of the cable because of thermal effects or wing flexure will move the plunger but will not operate the switch. Abnormal deflection of the cable will move the plunger enough to trip the switch. A shear pin protects the switch from excessive stress, and the spring loading causes the switch to operate as well if the shear pin or cable is broken.

The fuselage deformation switches (Fig. 6) are of strip construction and consist of metal contact strips held apart by spaced insulation strips and encased in a rubber sheath. The deformation from the weight of the

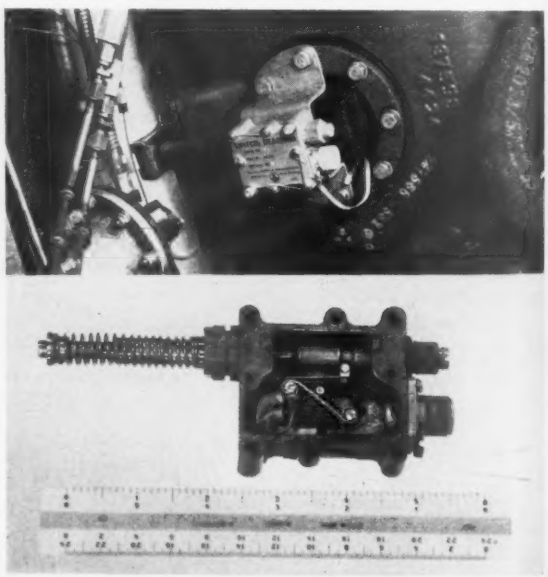

FIG. 4. Engine reaction switch.

airplane resting anywhere on the switch in contact with the ground will cause the strips to make contact and thus close the circuit. If the pressure is removed, the contact opens unless permanent damage is received. The switches are mounted on the underside of the fuselage, two 8-ft. lengths at the rear, one on each side, and one 4-ft. length centrally located at the front.

Actuation of an engine reaction switch or a wing deformation switch indicates that damage has been sustained and that the aircraft should be inerted if it is on the ground. Ground contact is established by simultaneous actuation of at least two of the three fuselage deformation switches installed. Actuation of both a reaction switch and a wing deformation switch on the same side of the airplane indicates that damage has been severe and fire is imminent. Under such conditions, it is assumed that the power which could be drawn from the affected nacelle is negligible, so inerting of that nacelle starts immediately, regardless of the relationship of the airplane to the ground.

Fig. 3 shows schematically the arrangement of the initiating system. Operation of any reaction switch or wing deformation switch partially completes a circuit through the control unit. Operation of the other initiating device in that wing completes the circuit to the relay and activates the inerting system in the nacelle on that side. If, subsequently, two of the three fuselage deformation switches are actuated simultaneously, an additional circuit will be completed, operating the inerting system for the entire airplane.

Whenever a reaction switch or a wing deformation switch is actuated, that circuit is electrically held closed for at least a 10-sec. interval even if the cause of actuation is removed. If the second initiator circuit is closed within this 10-sec. interval, the inerting system in the affected nacelle will be operated. Because of the requirement for simultaneous operation of the fuselage deformation switches to establish ground contact, no holding circuit is provided for these individual switches;

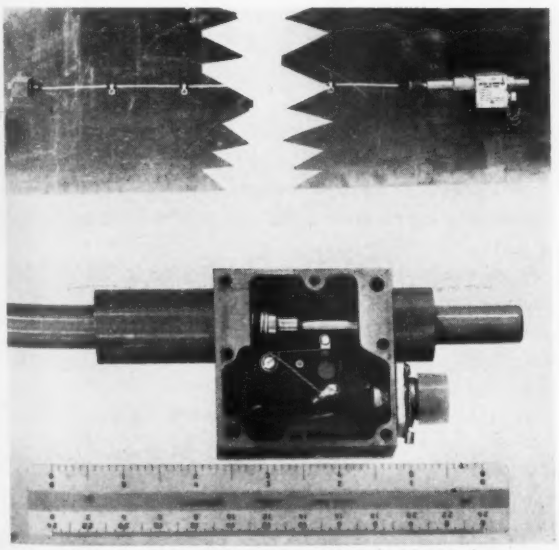

FIG. 5. Wing deformation switch (cable type).

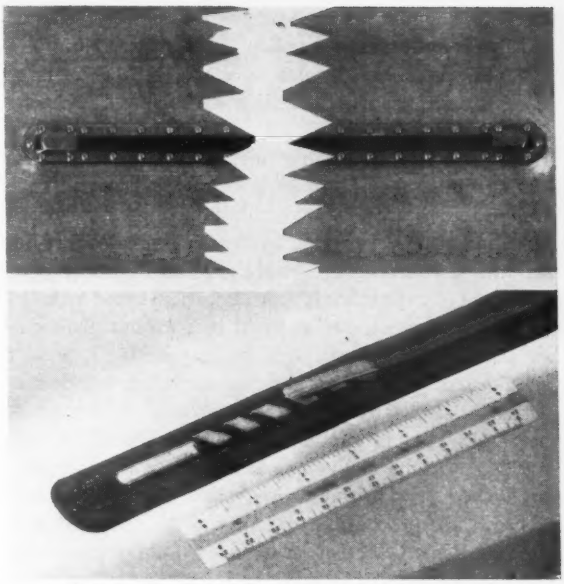

FIG. 6. Fuselage deformation switch (strip type).

but if simultaneous operation does occur, then the circuit is held closed for at least 10 sec. Should a reaction switch or wing deformation switch be operated in that interval, the airplane's entire inerting system would be operated.

A check-out circuit has been provided for a preflight checking of the system, including the condition of the various initiators and inerting devices and the operation of the relay circuits. Operating the check-out switch by the flight engineer removes the power source from the relays controlling the inerting devices. Then a motor-driven switch tests all initiating and inerting device wiring for continuity. Upon completion of the continuity check, a manual switch is cut in which permits the engineer, merely by advancing the switch one position each time, to check the operation of all initiator circuits and the operation of all relays. A double row of indicator lights is used as the visual indication. A row of amber lights acts as control lights, and the lighting of the corresponding light in the red row indicates that the circuit has functioned properly. Thus, the preflight test can give assurance that crash fire protection is provided and that no condition is present that would give inadvertent operation.

Numerous safety features are incorporated in the system. One, for example, is in the mechanism that closes the fuel valve. Here, compressed air is used from the engine exhaust cooling system. Because sufficient air pressure is available for about 20 sec. only and 45 sec. are required to stop the engine, a check valve is used to trap the air. A vent is provided, however, that allows the trapped air to bleed off in about 1 min. and thus permits the fuel valve to reopen if fuel pressure is restored. Another is in the bus grounding device. Here, the contactor that grounds the bus is mechanically interlocked with the battery contactor, so the bus cannot be grounded until the battery is disconnected.

However, should the bus be inadvertently grounded during flight, a 100-amp. overload circuit breaker is provided for protection. Such a circuit breaker is large enough to handle the residual power in the bus during a crash but would open if the energized bus should be grounded. Another important safety feature is the routing through separate conductors of all wires to the control unit that could, by coming in contact with each other, operate the inerting system. The pilot has before him a control panel containing an indicator light and a switch for each initiator circuit. Should an indicator light come on during flight indicating a malfunction or inadvertent operation in that initiator circuit, the pilot can, by opening the corresponding switch, de-energize that initiator circuit. The rest of the system is unaffected, and protection, although reduced, is still provided. A manually operated crash switch is also provided so that, in those cases where the pilot is able, the crash fire prevention system may be operated just prior to crash. Such a procedure would replace the present practice of cutting the engines prior to crash and would, of course, be more effective.

The development work has now been completed, and equipment has been fabricated that will withstand the effects of vibration, temperature extremes, moisture, and other standard Air Force environmental conditions.

Plans are now being made to install this equipment in two C-119 airplanes for a 300-hour flight test to verify its reliability under actual flight conditions. It is anticipated that several months will be required for this phase of the program.

The problem of crash fire prevention in jet or turbojet aircraft is not fundamentally different from that in reciprocating engine-powered aircraft. The prime ignition sources remain the hot surfaces of the engine, the spilled combustibles in the nacelles, and the electrical wires. Of course, the jet engine presents a different inerting problem than the reciprocating engine, but NACA has demonstrated that jet engines can be very effectively inerted by the proper application of coolant. The methods used were described by Irving Pinkel of NACA in a paper presented before this society.[4]

For the automatic initiating system, the crash sensing devices could still be the wing deformation switches and fuselage deformation switches. The engine reaction switch would be eliminated, and an engine pod breakaway switch substituted.

With little modification, therefore, the inerting, initiating, and control systems of the C-119 crash fire prevention system could be applied to jet aircraft.

The need for a practical means of preventing fire which usually follows the survivable type of crash has been evident through the years to those closely associated with aviation. The introduction of turbine transports in the not-too-distant future in regularly scheduled air-line operations gives new importance to this need.

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[1] Pinkel, I. Irving, Preston, G. Merritt, and Pesman, Gerard J., *Mechanism of Start and Development of Aircraft Crash Fires*, NACA Rep. 1133, 1954 (supersedes NACA RM E52F06).

[2] Towle, R., DiQuattro, R., and Fritsch, K., *Aircraft Crash Fire Protection System*. Walter Kidde & Co., Inc. (N. J.), January 6, 1954. (Contract AF-18(600)-167, E.O. No. SR-12 RDO-664.80A-4.)

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[4] Pinkel, I. Irving, *Crash-Fire Research with Jet Aircraft*, Aeronautical Engineering Review, Vol. 15, No. 1, pp. 53–57, January, 1956.

## VTOL-STOL Aircraft (*Continued from page 39*)

drag of service aircraft making possible substantial increase in speed ratio which signifies greater aircraft efficiency in terms of higher top speed, longer range, and shorter take-off and landing distance.

### Appendix—Derivation of Formulas

The ground run of an airplane during take-off can be calculated with sufficient accuracy by

$$S_g = V_{to}^2/2a \tag{1}$$

where $a = (g/W)T_{to}$ is horizontal acceleration.

Eq. (1) can be written as

$$S_g = W^2/S_w C_{Lto} \rho_0 g T_{to} \tag{2}$$

For a propeller-driven aircraft, the high speed is given by

$$V_{max} = (146{,}600\ THP_{hs}/C_{Dmin} S_w \sigma)^{1/3} \tag{3}$$

Combining Eqs. (2) and (3), we obtain

$$V^3_{max}/S_g = 11{,}220\ K_p$$

where

$$K_p = \frac{THP_{hs}}{W} \frac{T_{to}}{W} \frac{C_{Lto}}{C_{Dmin}} \frac{1}{\sigma} \tag{4}$$

is a constant for a given airplane.

A similar expression can be derived for a jet-propelled aircraft. In this case

$$V^2_{max}/S'_g = 29.9\ K_j$$

where

$$K_j = \frac{T_{hs}}{W} \frac{T_{to}}{W} \frac{C_{Lto}}{C_{Dmin}} \frac{1}{\sigma} \tag{5}$$

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# The In-Flight Collision Problem

*Cooperative collision warning and prevention vs. self-sufficient (or air-borne radar) systems.*

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Cornell Aeronautical Laboratory, Inc.

## Introduction

MUCH HAS been said in recent months about the increasing danger of inadvertent mid-air collision between airplanes in flight. Organizations representing various segments of the flying world have issued official statements of their concern, recognizing that air traffic control techniques and facilities have failed to keep pace with increasing traffic densities. Further evidence of the rising concern is given by the Mid-Air Collision Seminar[1] recently held at Indianapolis and by the formation of the Radio Technical Commission for Aeronautics, Special Committee 74, specifically aimed at this problem.

There is a division of opinion as to how this problem might best be solved. Many believe that the ultimate solution lies in rigid and precise control of all traffic at all times. Others consider that special-purpose, air-borne collision prevention equipments are necessary. Those favoring rigid control can point to a definition[2] of air traffic control's mission as requiring a "system whereby, under all weather conditions, aircraft are prevented from flying into each other without in any way impeding progress to their destinations." Proponents of the air-borne system can argue that precise and always reliable control of *all* traffic will not be possible, even in the projected future. Failures will always occur which will make individual self-protection desirable.

One could take the position that, even if a reliable air-borne collision warning capability were realized and used by *all* aircraft, no traffic control would be needed except in terminal areas. This would not materially affect present airport traffic acceptance problems since arrivals are nearly random in time now,[2] as would also be expected with no en route control. Such a concept is, of course, hard to accept since an infallible air-borne system would be as difficult to achieve as perfect air traffic control.

Questions of this type are seldom settled in a black-and-white fashion, and for the purposes of this discussion, a middle-of-the-road approach is assumed and a system is postulated possessing a maximum air-borne capability and a maximum air traffic control capability. This combination would have the double advantage of relaxing some of the traffic problems while at the same time providing pilots with an added degree of assurance against the occurrence of in-flight collisions.

This paper attempts to outline some of the basic elements germane to collision avoidance with air-borne systems and to fit these together in such a way that some insight into equipment (or system) design problems can be gained. Since the collision problem involves many economic, operational, and technical ramifications, no claim to completeness is made here. Instead, the author has tried to treat those elements which appeared to him most important and has, because of limited space, omitted some considerations.

The discussion begins with a brief résumé of collision statistics and then treats some of the problems of collision recognition and avoidance. Airplane range and angle coverage considerations are taken up next, and the final two sections describe and criticize the cooperative and self-sufficient system approaches.

## The Problem of Collision Avoidance

Approximately 95 per cent of the flying in the United States is done under visual flight rules† without strict control from the ground. Rigid control of air traffic is exercised only in instrument weather. It would be supposed therefore that most collisions would occur under VFR conditions, and this hypothesis is, in fact, supported by experience.[1] For example, of 172 civil aircraft collisions occurring between 1946 and 1952, only

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The author wishes to acknowledge the assistance of Edward H. Jocoy, Thomas L. Robinson, and Dr. Donald R. Rhodes of the Cornell Aeronautical Laboratory, Inc.

† 1,500-ft. ceiling and 3-mile visibility.

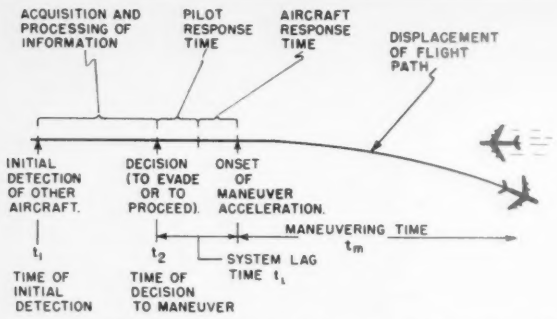


FIG. 1. Delineation of the basic elements of the process of collision avoidance.

one case specifically involved weather. Of 150 Air Force collisions in the $2^1/_2$ years prior to January, 1953, practically all happened in VFR weather, and the same was true of 23 Navy aircraft collisions during the period April, 1953, to June, 1955.* These figures seem to indicate that the greatest collision threat exists when flying weather is good and point to the potential utility of a system that would merely alert pilots and leave avoidance to visual means.

It is true, however, that as aircraft speeds increase, visual detection can no longer be relied upon. This, coupled with the loss of visual capability in conditions of poor visibility, creates a need for an all-weather collision warning capability. The problem therefore divides into areas of

(1) Fair-weather flight at speeds low enough to allow visual avoidance after a simple collision alert.

(2) All-weather flight and all aircraft speeds with reliance upon some electronic system to provide all the necessary data to accomplish safe clearance.

Regardless of what the specific means for collision avoidance happens to be, the overall process can be divided into the phases shown in Fig. 1. These are initial detection (range-angle requirements), acquisition of information, processing of information (decision), and pilot and aircraft response. Therefore, before discussing specific means for collision prevention, it is necessary to examine these individual functions.

## Collision Recognition

To recognize a collision threat in advance, information must be obtained about the relative position and relative motion of the approaching aircraft. To examine these factors, refer to Fig. 2. Here, aircraft $A_1$ and $A_2$ are assumed to fly straight, constant-speed paths. The coordinate system shown is moving (relative to the ground) with $A_1$ at its origin, the $y$-axis coincident with $V_1$, the velocity vector of $A_1$, and the $x$-axis horizontal relative to the aircraft wings. In this frame of reference, either of the following equations describes a necessary and sufficient condition for a collision to occur:

$$\dot{\delta}(t) = 0 \tag{1}$$

or

$$\dot{s}(t) = \text{constant} < 0 \tag{2}$$

where $\dot{\delta}(t)$ and $\dot{s}(t)$ are time derivatives of bearing angle and range. It will also be seen that, if $\epsilon_\delta$ and $\epsilon_s$ are small constants and

$$\dot{\delta}(t) = \epsilon_\delta \neq 0 \tag{3}$$

or

$$\dot{s}(t) = \epsilon_s \neq 0 \tag{4}$$

for any given time, the smaller $\epsilon_\delta$ and $\epsilon_s$, the smaller the ultimate miss-distance ($s_m$) will be.

If we could measure $\dot{\delta}(t)$ or $\dot{s}(t)$ without error, we could evidently predict an impending collision. Also, we could predict near misses by observing the magnitudes of $\epsilon_\delta$ and $\epsilon_s$.† An appropriate maneuver could then be chosen to increase the expected miss-distance.

Notice also from Fig. 2 that, for $z(t) = 0$ if $\dot{\delta}(t) < 0$, $A_2$ will pass in front of $A_1$—and behind it if $\dot{\delta}(t) > 0$. These facts can be helpful in choosing the appropriate evasive maneuver.

To illustrate the behavior of some of these parameters for different geometric conditions, the examples in Tables 1 through 4 were calculated. These were done for $z(t) = 0$ in which case $\beta(t) = \delta(t)$. The values of $V_1$, $V_2$, $s_m$, and $\theta$ used are listed for each table. Time of travel to the point of closest proximity is denoted by $t$, and $\theta$ represents the angle (in space) between the flight paths of $A_2$ and $A_1$—e.g., $\theta = 0$ denotes parallel courses with $A_1$ and $A_2$ approaching head-on. The quotient $s(t)/|\dot{s}(t)|$ gives an estimate of the closure time and is denoted by $t_c$.

The extremely small values of $\dot{\beta}(t)$ and $\dot{s}(t)$ for large ranges make it impractical to measure these quantities from an aircraft without a considerable amount of integration time. By observing variations in $\beta(t)$, $\dot{\beta}(t)$, etc., for several seconds, however, it becomes possible to es-

† These statements presume, of course, that both aircraft velocities are constant.

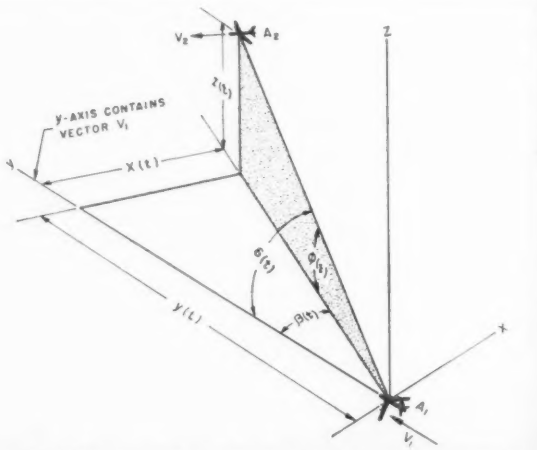


FIG. 2. Moving coordinate system showing pertinent quantities for collision recognition.

* Collisions occurring in formation flight, etc., are not included.

timate the degree of collision threat by using the criteria of Eqs. (1), (2), (3), and (4). It should be pointed out, however, that observation of these quantities is not the only way of avoiding a potential collision. For example, the simple expedient of flying $A_1$ in such a way that $|z(t)| > 0$ for all $t$ will assure clearance—but not without certain operational penalties. Other simple techniques of a similar nature can be employed, and some of these are described later.

The accuracy with which one is able to predict the future path of an approaching aircraft is a major factor in deciding what maximum detection range is required. For this reason, let us examine a particular case. For simplification we look only at the two-dimensional case and set $z(t) = 0$.

Fig. 3 illustrates a simple method of position prediction using two-point linear extrapolation of $A_2$'s motion in the $x$-$y$ plane. At $t = t_1$ a position measurement is made, and $t_2 - t_1$ sec. later a second measurement is made. It is assumed that the distribution of errors will be symmetrical about the measured points $P_1$ and $P_2$, and we draw circles about them of radii $\epsilon s(t_1)$ and $\epsilon s(t_2)$ such that the probability that $A_2$ is actually within the circles is some reasonable value. The most probable path of $A_2$ is therefore the line through $P_1$ and $P_2$ designated $L_m$. The radius of the predicted circle is given by

$$R_p = \frac{\epsilon t_p}{t_2 - t_1} [s(t_1) + s(t_2)] + \epsilon s(t_2) \qquad (5)$$

where $t_p$ is the prediction time (measured after $t_2$), and $\epsilon$ is the mil-error in angular measurement.

As an example, let $t_1 = 0$ sec., $s(0) = 60{,}000$ ft., $t_2 = 20$ sec., $s(20) = 30{,}000$ ft., $t_p = 20$ sec., and $\epsilon = 1/60$.* Substituting these in Eq. (5), $R_p = 2{,}000$ ft., $L_m$ passes through the origin, and the data indicate a maximum probability of collision at $t = 40$.

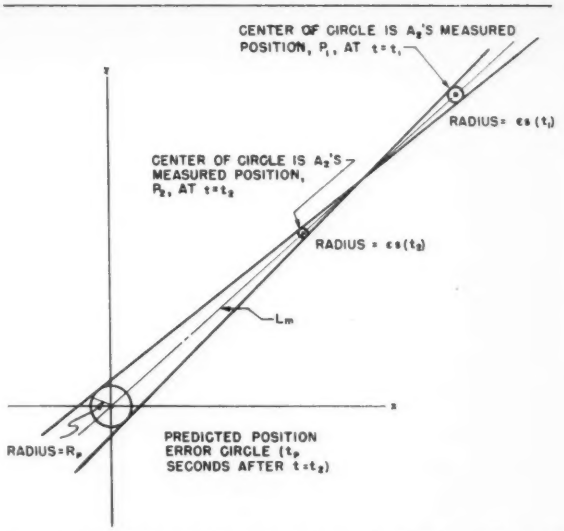
CENTER OF CIRCLE IS A₂'S MEASURED POSITION, P₁, AT t=t₁
RADIUS= εs(t₁)
CENTER OF CIRCLE IS A₂'S MEASURED POSITION, P₂, AT t=t₂
RADIUS = εs(t₂)
Lm
y
x
RADIUS=Rp
PREDICTED POSITION ERROR CIRCLE (tp SECONDS AFTER t=t₂)

FIG. 3. Prediction of future path of $A_2$ showing effects of position errors.

## EVASION

The question of what evasive maneuver is optimum for a given situation is complicated, particularly when

* This would correspond roughly to an angular error of ±1° in azimuth and a range error of ±1,000 ft. at $s(40) = 60{,}000$ ft. In practice, one would normally use more than two points for the extrapolation with a corresponding decrease in expected prediction error.

TABLE 1
$V_1 = V_2 = 1{,}000$ fps; $s_m = 1{,}000$ ft.; $\theta = 0°$

| $t$ sec. | $s(t)$ ft. | $\lvert \dot{s}(t) \rvert$ fps | $\ddot{s}(t)$ fps/sec. | $\beta(t)$ deg. | $\dot{\beta}(t)$ deg./sec. | $t_c = \frac{s(t)}{\lvert \dot{s}(t) \rvert}$ sec. |
|---|---|---|---|---|---|---|
| 60 | 120,004 | 1,999.9 | 0.0023 | 0.48 | 0.008 | 60.0 |
| 30 | 60,008 | 1,999.7 | 0.0185 | 0.96 | 0.032 | 30.0 |
| 25 | 50,010 | 1,999.6 | 0.0319 | 1.15 | 0.046 | 25.0 |
| 20 | 40,012 | 1,999.4 | 0.0624 | 1.43 | 0.072 | 20.0 |
| 15 | 30,017 | 1,998.9 | 0.1479 | 1.91 | 0.127 | 15.0 |
| 10 | 20,025 | 1,997.5 | 0.4981 | 2.86 | 0.286 | 10.0 |
| 5 | 10,050 | 1,990.1 | 3.9407 | 5.71 | 1.135 | 5.0 |
| 0 | 1,000 | 0 | 4,000.00 | 90.00 | 114.592 | ∞ |

TABLE 2
$V_1 = V_2 = 1{,}000$ fps; $s_m = 3{,}000$ ft.; $\theta = 0°$

| $t$ sec. | $s(t)$ ft. | $\lvert \dot{s}(t) \rvert$ fps | $\ddot{s}(t)$ fps/sec. | $\beta(t)$ deg. | $\dot{\beta}(t)$ deg./sec. | $t_c = \frac{s(t)}{\lvert \dot{s}(t) \rvert}$ sec. |
|---|---|---|---|---|---|---|
| 60 | 120,037 | 1,999.4 | 0.0208 | 1.43 | 0.024 | 60.0 |
| 30 | 60,075 | 1,997.5 | 0.1660 | 2.86 | 0.095 | 30.1 |
| 25 | 50,090 | 1,996.4 | 0.2864 | 3.43 | 0.137 | 25.1 |
| 20 | 40,112 | 1,994.4 | 0.5577 | 4.29 | 0.214 | 20.0 |
| 15 | 30,150 | 1,990.1 | 1.3135 | 5.71 | 0.378 | 15.1 |
| 10 | 20,224 | 1,977.9 | 4.3522 | 8.53 | 0.840 | 10.2 |
| 5 | 10,440 | 1,915.7 | 31.6346 | 16.70 | 3.154 | 54.5 |
| 0 | 3,000 | 0 | 1,333.3333 | 90.00 | 38.197 | ∞ |

TABLE 3
$V_1 = V_2 = 1{,}000$ fps; $s_m = 1{,}000$ ft.; $\theta = 90°$

| $t$ sec. | $s(t)$ ft. | $\lvert \dot{s}(t) \rvert$ fps | $\ddot{s}(t)$ fps/sec. | $\beta(t)$ deg. | $\dot{\beta}(t)$ deg./sec. | $t_c = \frac{s(t)}{\lvert \dot{s}(t) \rvert}$ sec. |
|---|---|---|---|---|---|---|
| 60 | 84,859 | 1,414.0 | 0.0032 | 45.68 | 0.011 | 60.0 |
| 30 | 42,438 | 1,413.8 | 0.0261 | 46.35 | 0.045 | 30.0 |
| 25 | 35,369 | 1,413.6 | 0.0452 | 46.62 | 0.065 | 25.0 |
| 20 | 28,302 | 1,413.3 | 0.0882 | 47.02 | 0.101 | 20.0 |
| 15 | 21,237 | 1,412.6 | 0.2088 | 47.70 | 0.180 | 15.0 |
| 10 | 14,177 | 1,410.7 | 0.7018 | 49.04 | 0.403 | 10.0 |
| 5 | 7,141 | 1,400.3 | 5.4912 | 53.05 | 1.589 | 5.1 |
| 0 | 1,000 | 0 | 2,000.00 | 180.00 | 81.029 | ∞ |

TABLE 4
$V_1 = V_2 = 1{,}000$ fps; $s_m = 3{,}000$ ft.; $\theta = 90°$

| $t$ sec. | $s(t)$ ft. | $\lvert \dot{s}(t) \rvert$ fps | $\ddot{s}(t)$ fps/sec. | $\beta(t)$ deg. | $\dot{\beta}(t)$ deg./sec. | $t_c = \frac{s(t)}{\lvert \dot{s}(t) \rvert}$ sec. |
|---|---|---|---|---|---|---|
| 60 | 84,906 | 1,413.3 | 0.0294 | 47.02 | 0.034 | 60.1 |
| 30 | 42,532 | 1,410.7 | 0.2339 | 49.04 | 0.134 | 30.1 |
| 25 | 35,482 | 1,409.1 | 0.4029 | 49.85 | 0.193 | 25.2 |
| 20 | 28,443 | 1,406.3 | 0.7822 | 51.05 | 0.300 | 20.2 |
| 15 | 21,424 | 1,400.3 | 1.8304 | 53.05 | 0.530 | 15.3 |
| 10 | 14,457 | 1,383.4 | 5.9573 | 56.98 | 1.163 | 10.4 |
| 5 | 7,681 | 1,301.9 | 39.7186 | 67.99 | 4.120 | 5.9 |
| 0 | 3,000 | 0 | 666.6667 | 180.00 | 27.01 | ∞ |

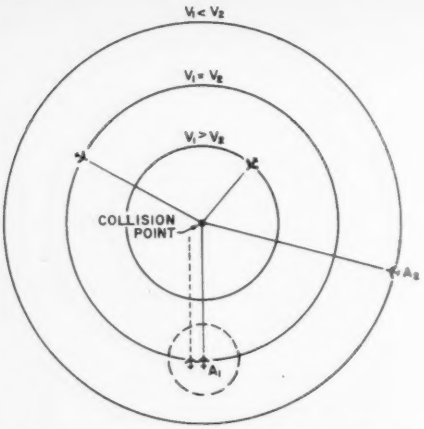


FIG. 4. Angular coverage required by $A_1$ for $V_1 > V_2$, $V_1 = V_2$, and $V_1 < V_2$. Solid circles are for constant closure time. Dotted circle is for short-range detection regardless of closure time.

one considers the possibility of both aircraft maneuvering simultaneously to avoid each other. In this case, one is immediately involved in trying to establish "rules of the road" to forestall situations where the dual maneuvers counteract each other. The complicated character of these problems prohibits any thought of adequate treatment in this article, and, for this reason, only maneuvering capabilities are discussed. These include consideration of turns, deceleration, and pull-ups.

If an aircraft flying a straight, constant-speed course enters a constant-speed, constant-acceleration turn, after $t_m$ sec. it displaces itself laterally by a distance

$$x_a(t_m) = (V^2/a)[1 - \cos(a/V)t_m] \quad (6)$$

$$\cong 1/2\, at_m^2 \quad (7)$$

and longitudinally, by

$$y_a(t_m) = (V^2/a)[(a/V)t_m - \sin(a/V)t_m] \quad (8)$$

In these equations, $V$ is the aircraft speed, and $a$ is the acceleration. Table 5 lists $x_a(t_m)$ and $y_a(t_m)$ for typical values of $a$ and $V$.

Longitudinal displacement can also be accomplished by deceleration.[3] Typical achievable values are tabulated in Table 6 for a propeller-driven transport with initial speed of 400 ft. per sec. and for a jet transport with initial speed of 670 ft. per sec. In both instances, deceleration is accomplished by closing the throttles, but, in the case of the jet, a drag brake is also considered. An average deceleration of 1.5 ft. per sec./sec. is used for the propeller aircraft, 1.6 ft. per sec./sec. for the jet without drag brake, and 4.0 ft. per sec./sec. with brakes. From these, it appears that additional reduction of collision probability could be achieved if the slow-down maneuver were employed in conjunction with an appropriate turn. This would increase $y_a(t_m)$ by slowing the aircraft and shortening the turning radius.

The pilot has another alternative for evasion, that of changing altitude. Pull-up or push-over maneuvers have the advantage of being simpler to perform and quicker to initiate than coordinated turns. The time delay between the initiation of control displacement and actual onset of the vertical acceleration will vary with aircraft types, but a reasonable average is about 1 sec. For turns, depending upon the twisting rate, figures from 2 to 5 sec. are representative. Thus, because of the time-saving, in many cases the vertical maneuver would be the best.

The pull-up coupled with a deceleration maneuver (closing throttle) not only increases vertical separation but introduces larger values of longitudinal displacement as well.[3] With the piston aircraft of the previous example, if a 1,000 ft. per min. climb is initiated simultaneously while closing the throttles, the decelerations used in Table 6 will be doubled (3.0 ft. per sec./sec.) doubling the displacement values. In addition, appreciable vertical displacements result. Introducing a 1,500 ft. per min. climb with the jet transport approximately doubles the deceleration (3.3 ft. per sec./sec.) and displacement values listed for the no-brake case.

It is clear that in many cases the vertical maneuver offers advantages and would be the optimum for evasion. However, choice of the appropriate evasive tactic will depend upon the amount and type of information available to the pilot (or computer) and the particular circumstances. If the specific system in use presents only a restricted amount of information, then it can demand only certain maneuvers. There will also be cases when, because more than one aircraft has to be avoided, the choice of maneuver will be influenced by this fact.

## RANGE-ANGLE COVERAGE DIAGRAMS

To collide with $A_1$, $A_2$ must lie on the circumference of a circle with center at the collision point and radius equal to the product of $V_2$ and the time to collision. Three such circles are shown in Fig. 4. These show that

TABLE 5
Values of $x_a(t_m)$ and $y_a(t_m)$ for $V$ = 1,000 fps, and $a$ = 15 fps/sec. and 30 fps/sec.

| | $a$ = 15 fps/sec. | | $a$ = 30 fps/sec. | |
|---|---|---|---|---|
| $t_m$ | $x_a(t_m)$ ft. | $y_a(t_m)$ ft. | $x_a(t_m)$ ft. | $y_a(t_m)$ ft. |
| 0 | 0 | 0 | 0 | 0 |
| 5 | 187 | 5 | 374 | 19 |
| 10 | 748 | 37 | 1,489 | 149 |
| 15 | 1,680 | 126 | 3,319 | 501 |
| 20 | 2,977 | 299 | 5,823 | 1,179 |
| 25 | 4,632 | 582 | 8,946 | 2,279 |
| 30 | 6,636 | 1,002 | 12,616 | 3,890 |

TABLE 6
Values of $y_a(t_m)$ for Decelerating Propeller-Driven and Jet Aircraft

| | | Jet Aircraft | |
|---|---|---|---|
| $t_m$ | Piston Aircraft, ft. | No drag brake, ft. | With drag brake, ft. |
| 0 | 0 | 0 | 0 |
| 5 | 19 | 20 | 50 |
| 10 | 75 | 80 | 200 |
| 15 | 169 | 180 | 450 |
| 20 | 300 | 320 | 800 |
| 25 | 469 | 500 | 1,250 |
| 30 | 675 | 720 | 1,800 |

coverage of the forward 180° will protect $A_1$ against all aircraft having speeds equal to or less than $V_1$. For protection against higher speed aircraft, 360° coverage is required—but with considerably less range to the rear than to the front.

The coverage circles shown would give constant warning times, except for the small dotted circle which is required for cases where $s(t)$ is small and $t_c$ is large (airplane to left of $A_1$). In this case, if no warning is given, a small shift in course by either aircraft could cause a collision without sufficient warning time. The dotted-circle coverage is to take care of these cases.

Maximum detection range needed can be estimated if we assume that a maneuver displacing $A_1$ by $R_p$ ft. will reduce the collision probability to an acceptably low level. Neglecting longitudinal and considering only lateral maneuvering displacement, we require that $x_a(t_m) = R_p$. Therefore, substituting $1/2\, at_m^2$ for $R_p$ in Eq. (5) and remembering that $t_L + t_m = t_p$ (see Fig. 1), we can solve for $t_p$. If we take $a = 15$ ft. per sec./sec., $V_1 = V_2 = 1{,}000$ ft. per sec., $t_L = 6$ sec.,* $\epsilon = 1/60$, $t_1 = 0$, $t_2 = 20$, $s(0) = (20 + t_p)(V_1 + V_2)$, and $s(20) = t_p(V_1 + V_2)$ and compute $t_p$, we obtain a value of 36 sec. The total warning time required is therefore 56 sec., and the maximum detection range is $(V_1 + V_2)t_p \approx 21$ miles. Improved accuracy (smaller $\epsilon$) of prediction would result in a decreased range requirement.

Vertical coverage requirements can be specified conveniently in altitude. Assuming $A_1$ to be in level flight, consider $A_2$'s maximum vertical speed to be $\pm \dot{z}(t)$. For $t_w$ sec. warning, then, the altitudes between $\pm \dot{z}(t)t_w$ must be protected. Thus, for $t_w = 60$ sec. and $\dot{z}(t) = 4{,}000$ ft. per min., relative altitudes between $\pm$ 4,000 ft. must be protected.

Since airplanes do not fly at the same speed during all phases of their operation and since the required coverage patterns will depend upon $V_1$ and $V_2$, this factor must be considered. Let us suppose, for example, that $A_1$ enters a high density area where maximum speeds are required to be substantially less than normal cruising speeds. A pattern developed for cruising speeds would then be too large and could result in too frequent alerts (depending upon the system used). To prevent this would require a special coverage configuration established for the new values of $V_1$ and $V_2$ and to be used only when entering airport traffic patterns.

At first glance, one might wonder why it is necessary to restrict the detection range at all. Why not try to detect other aircraft at the maximum possible range and thereby ensure adequate warning? The difficulty lies in the fact that *too much* range with some systems can result in too many unnecessary alerts. If such were the case, in high density areas, the frequency of alerts could be so high as to render the warning device useless. At best, handling a multiplicity of detected aircraft simultaneously will be difficult, and restriction of detection ranges to reasonable limits is one way of providing partial relief of the problem.

Further information about angular coverage requirements for various combinations of speeds, straight and curved paths, and climbing and descending configurations is available in reference 4.

## Cooperative Collision Warning Systems

Several systems have been proposed for collision warning and prevention which depend upon cooperative equipment in the aircraft involved. Generally speaking, these systems would employ radio transmitters in each aircraft to broadcast their presence and perhaps other information useful for collison warning. One of the simplest cooperative systems requires that one aircraft carry a transmitter which continuously emits radio frequency pulses detectable by receivers carried in other aircraft. No range or bearing information is available to the pilot of the receiver aircraft, but, in VFR weather, the mere fact that he would be alerted would tend to decrease the probability of collision because he could attempt to locate the other aircraft visually. In practice, of course, both aircraft could carry a transmitter and a receiver.

This simple system would result in hopeless confusion in heavy traffic. Also, in weather where visibility is restricted, it would be totally inadequate, and pilots would be better off with no equipment at all.

Several methods can be used to enhance the simple system, and each of these involves means for measuring one or more of the geometric quantities discussed previously. For example, one scheme would code the transmissions to convey altitude information. This could be done by controlling the transmitted pulse widths or pulse repetition rates or by associating the transmitter and receiver frequencies with altitudes. These three methods are illustrated in Figs. 5, 6, and 7 and might employ a calibrated barometric pressure cell transducer to provide modulator data inputs. From a circuit viewpoint, this would not be difficult to accomplish.

The systems of Figs. 5 and 6 would be arranged to warn the pilot only when signals received indicate that the other aircraft is within some specified altitude range close to his own. A serious problem appears, however if more than one transmission is received simultaneously. Even if the aircraft are widely spaced in altitude, it becomes difficult to separate their transmission and extract altitude data.

The problem presented by multiple signals is somewhat relieved by making the transmitter and receiver frequencies proportional to altitude. This means that they will only receive signals from other aircraft occupying an altitude band close to their own. Thus, an airplane passing above or below† some predetermined altitude band would not be detected. However, per-

* This allows 1 sec. for pilot response (assuming he was alerted at $t = t_1$) and 5 sec. for airplane response.

† The altitude resolution here would depend upon the bandwidth of the particular receiver used.

tinent transmissions corresponding to aircraft at altitudes near that of the receiver would be detected. This method would reduce the multiple signal problem by limiting communication to aircraft in a narrow band of altitudes, all others being excluded. Confusion would still result if transmissions were received from more than one airplane appearing in the altitude band being guarded.

All three of these systems demand evasion by pull-up or push-over and would require action in all cases where another aircraft signals approach at or near the own-ship altitude. Should either aircraft be in a descending or ascending altitude, in the absence of further information it becomes necessary to maneuver in such a way that the two aircraft altitudes never cross. This means that, if $A_2$ were climbing when detected but was below $A_1$, the pilot of $A_1$ would have to initiate a climb sufficient to keep $A_2$ below him until the two have passed. The same applies, of course, to the descending case.

Such arbitrary shifting of altitude would, to say the least, be undesirable from a traffic control point of view and could indeed result in increased exposure to collision with aircraft at other altitudes. This is particularly bad if the transmitter and receiver combinations have appreciable ranges. If, for example, reliable contact at ranges of 20 miles were made, this would mean that $A_1$ would have to climb or descend to a different altitude (temporarily) even if the other aircraft passed 20 miles away. Means for relieving this undesirable characteristic of the system must therefore be sought.

Because of its altitude discrimination capability, let us choose the proportional frequency method and add to it a means for measuring bearing angle (azimuth only). In this case, $A_1$ would be advised not only of $A_2$'s relative altitude but of its bearing as well. Two methods of measuring $\beta(t)$ are illustrated in Figs. 8 and 9. One employs a rotating null technique, and the other utilizes a pencil beam antenna.

In Fig. 8 it may be seen that strong signals would be received from $A_2$ for all orientation of $A_1$'s antenna pattern except during the passage of the null through the actual $A_2$ bearing angle. If one plotted signal strength and $\beta(t)$ in the manner of Fig. 10, sharp bearing information would be obtained.

A similar display for the swept-beam system is shown in Fig. 11. Here, of course, a maximum appears instead of a null, and, unless an extremely sharp beam is used, inferior angular resolution would result. Realization of even moderate directivity implies the use of an antenna with large physical dimensions even at microwave frequencies. The nulling system can be accomplished with smaller antennas. For this reason, the null method would appear to be most feasible, although in some special applications it is conceivable that the pencil beam method would be more suitable.

The system in Fig. 8 would in some measure eliminate the difficulties encountered with the simple nondirectional proportional-frequency system by indicating bearing angle to the pilot from which, by continuous observations, he could estimate $\dot{\beta}(t)$. In this way, for cases where the miss distance is to be large, $\beta(t)$ will vary a sufficient amount to indicate safe crossing.

The degree to which $\beta(t)$ and $\dot{\beta}(t)$ can be used in this way will depend upon the angular resolution obtainable which will be affected by such things as signal strengths, system calibration, and short-term variations in the directional attitude of the measuring aircraft.*

At the cost of weight, space, and complexity, a range-measuring capability could be incorporated in each of the systems discussed. This cost might be justified, however, by improved performance with respect to operation in high density areas and by further reducing the number of unnecessary course deviations.

## Difficulties with Cooperative Systems

One underlying and ponderous difficulty with cooperative systems that must be considered is that, for complete insurance against collision, *all* aircraft must be fitted with the appropriate cooperative equipment. The magnitude of this job is indicated by the fact that there are presently about 26,500 USAF airplanes, 12,500 Navy, 3,500 Army, 2,000 air carriers (domestic and international), and 97,000 aircraft of other categories in this country—a total of approximately 141,500 airplanes.[5] To enforce installation of collision warning equipment in a significant portion of these would seem to present some staggering, almost insurmountable obstacles. Even as late as 1953, in the general aviation category† of civil aviation, there were some 38 per cent of 61,000 active airplanes without *any radio equipment whatever*.[6] While the situation is no doubt more favorable today, these figures do give an indication of what it might be like to try to sell collision equipment in that aircraft category. Add to this the difficulties likely to be encountered in picking a system agreeable to all categories, and it is easy to become discouraged.

Another problem evolves with cooperative systems which is perhaps less serious but nevertheless real. This is the undesirable situation of forcing the pilot to depend not only on his own equipment but upon apparatus in other aircraft. Even if all aircraft were suitably equipped, direct failures and misalignment of components would leave much room for overall system breakdown, and the knowledge of this would not breed pilot confidence.

## Air-Borne Radar

The quickest way to provide any given airplane with collision protection is to equip it with a device which can detect and track other aircraft independently. That this is more difficult to achieve *technically* than some forms of cooperative system is perhaps true, but

* This source of error can be eliminated largely by stabilizing bearing data with respect to a directional gyro.

† This does not include military or air carrier aircraft.

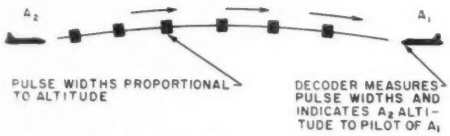


FIG. 5. Cooperative system with pulse width proportional to $A_2$ altitude.

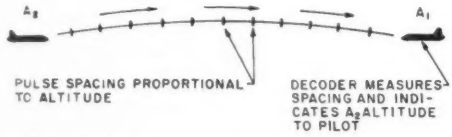


FIG. 6. Cooperative system with pulse spacing proportional to $A_2$ altitude.

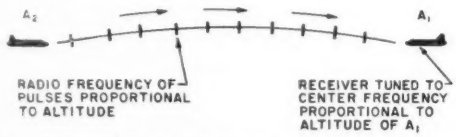
$A_2$
$A_1$
RADIO FREQUENCY OF PULSES PROPORTIONAL TO ALTITUDE
RECEIVER TUNED TO CENTER FREQUENCY PROPORTIONAL TO ALTITUDE OF $A_1$

FIG. 7. Cooperative system with transmitter frequency proportional to $A_2$ altitude.

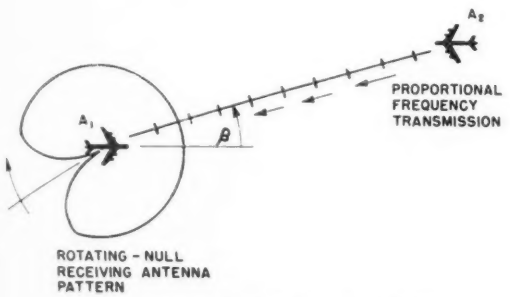


FIG. 8. Null method of determining $\beta(t)$.

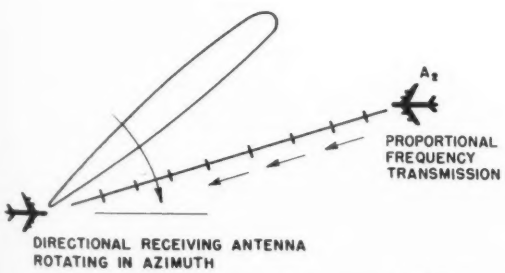


FIG. 9. Directional antenna for measuring $\beta(t)$.

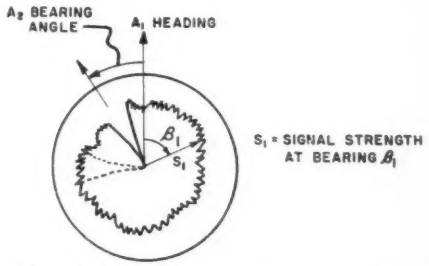


FIG. 10. Method of displaying null orientation for measurement of $\beta(t)$.

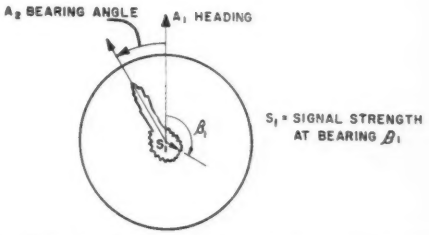


FIG. 11. Method of displaying bearing angle with swept beam system.

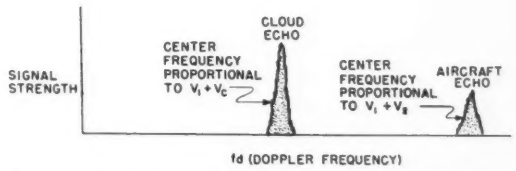


FIG. 12. Doppler spectra from cloud and aircraft of Fig. 13.

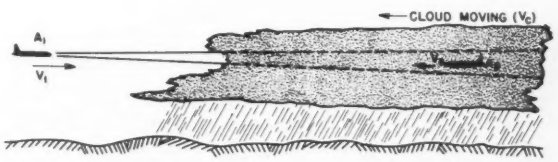


FIG. 13. Radar shown looking into cloud and illuminating other aircraft. Doppler shifts from cloud and aircraft are shown in Fig. 12.

the technical difficulties are balanced by the operational problems associated with implementing and maintaining a cooperative system. For these reasons, it appears worth while to have a look at what is involved in trying to accomplish a self-sufficient collision warning capability.

It is unfortunate that the negative results of tests conducted to date[7, 8] to determine whether air-borne radar is useful for collision prevention have been interpreted as applying to air-borne radar in general. While the radars used in these programs were adequate for weather probing, they could not have been expected to function well in a collision warning capacity. The job of air-to-air detection is sufficiently difficult that, to get good results, one must design a radar with this job specifically in mind. Having done this, it is more probable that the results will be favorable.

If one takes the electrical characteristics of the radars used by American Airlines, Inc., and United Air Lines, Inc., and estimates probable detection ranges in the manner of references 9 and 10, he will find that the experimental results actually agree well with theory. But the absolute values of ranges thus calculated are less important than questions of ground and weather echo masking of the aircraft target and of a pilot's ability to see and recognize an aircraft echo. The question of compatibility with other operational functions is also important.

Ignoring the effects of clutter for the moment and considering the case where an operator attempts to see and recognize a small echo on a plan-position indicator, there are two paramount problems. The first of these has to do with operator attention—he must be looking at the scope before he can detect a target. The second factor has to do with the observer's ability to detect and identify aircraft echoes under the adverse conditions found in the air-borne environment. In this respect, fatigue and ambient light effects can act to reduce materially detection ranges and therefore the utility of the instrument. While the operator factor varies greatly under different conditions and is not easily predicted, there is general agreement that the air-borne operator is some 10 to 15 db. "worse" than the ground or ship-borne observer. The result is an approximate halving of detection ranges in the air-borne case.

The question of weather and ground clutter is more serious. Even the best operator cannot detect a target hopelessly masked in large echoes from the ground or from weather. Short of placing a beacon in the other aircraft (and reverting to a cooperative system), utilization of some form of doppler radar seems to be the best approach for effecting a self-sufficient collision warning system. Doppler techniques offer a means for sharply reducing the masking effects of clutter and provide a means for accomplishing automatic signal detection, thereby relieving the operator problem considerably.[11, 12]

Space will not permit discussion of specific means for accomplishing this, but we can discuss the basic features of a system of this type. Let us, therefore, briefly discuss the doppler effect and see how it might prove useful in the air-borne radar application.

The so-called doppler effect is a phenomenon that one observes when receiving radiated energy from moving objects. With a radar, for example, if one transmits electromagnetic energy at a known frequency, signals reflected from surfaces within the radar antenna pattern will exhibit, when detected, the same frequency as the transmitter for stationary (relative to the radar) targets and different frequencies for moving targets. The frequency shift is a function of target-to-radar relative speed and transmitter wave length and is described by the doppler equation, $f_d = 89.4\ (V/\lambda)$, where $V$ is the relative velocity in miles-per-hour, and $\lambda$ is the transmitter wave length in centimeters.[13] Thus, a C-band radar ($\lambda \approx 6$ cm.) will yield approximately 15 cycles per sec./m.p.h. of doppler shift.

Let us now imagine a radar capable of detecting the doppler shift in reflected energy and examine the character of signals associated with typical targets. Fig. 12 shows the doppler spectra one might expect from a moving cloud and from another aircraft (Fig. 13). The two signals are seen to have different frequency content and are therefore separable, except in cases where the closure rate of $A_2$ is near the closure rate of the cloud. The same thing occurs in the case of ground return, except that the spectra here will have a center frequency approximately proportional to $V_1$ ($A_1$ ground speed).

The aircraft echo of Fig. 12 does not illustrate the fact that the echoes received from propeller-driven aircraft will generally have a considerable amount of amplitude and frequency modulation and thus, if detected by audible means, would be identifiable.[11] Experienced observers are able to distinguish between single and multiengined aircraft in this way. This effect could have particular utility in a collision warning sense by providing a means for identification of targets.

Consideration of the fact that doppler radars detect things that move leads one to the possibility of using this technique for location of turbulence.* Present search radar methods depend upon a correlation between heavy turbulence and high echo intensity gradients, and, while this method has been proved to give good results,[7, 8] an improved capability could result if the doppler technique were employed. Identification would depend only upon the existence of detectable echoes (from a power standpoint) and motion of the reflecting particles (rain, hail, etc.). As stated before, however, the doppler shift occurs only when the reflecting particles have velocity components in the direction of the radar. This would mean that large vertical wind velocities—as found in thunderstorms—would not, in themselves, be detectable if viewed horizontally. Vortices or eddies would, however, have such velocity components that they would be detectable. While at first glance this

* No direct experimental evidence has been found to verify that turbulence can, in fact, be detected in this way. From a theoretical standpoint, however, there is good reason to believe that it can be done.

would appear to be a serious disadvantage, it was found by the flight crews of the Thunderstorm Project[14] that these eddies (or gusts) were the principal causes of "heavy" turbulence reports and that large vertical drafts were of secondary importance. This apparently was due to the fact that gusts caused large changes in roll, pitch, and yaw, while the drafts gave only systematic changes in altitude. Direct detection of gusts would therefore appear desirable.

The air-borne weather radar tests reported in reference 8 showed that the type of radar used could not be relied upon for detection of tornadoes. These are perhaps the most dangerous weather phenomena confronting pilots. To the author's knowledge, no one has yet had the experience of observing a tornado with a doppler radar, but it can well be imagined what the doppler spectra in a tornado echo would be like. With internal wind speeds variously estimated at from 100 to 500 m.p.h., the doppler signature from a tornado should be unmistakable. It therefore appears that the doppler technique may have utility for detection and identification of tornadoes, as well as its other potentialities for turbulence and aircraft detection.

## Automatic Detection of Aircraft

By making possible separation of aircraft echoes from clutter, the doppler technique affords the opportunity to provide an automatic warning of approaching aircraft. This, coupled with a device for artificially intensifying a particular moving echo on the PPI, would greatly reduce operator losses and increase the radar detection range. Even this, however, would leave it up to the pilot (or radar observer) to track the echo visually and decide whether a collision threat existed. A much better arrangement would be to equip the system with appropriate computing elements to predict impending collisions and to establish the appropriate evasive maneuver. This could be accomplished in a manner similar to that of Fig. 3 (but using more than two points for extrapolation) with the addition of rate information in the form of the doppler shift. The rate information will improve the prediction accuracy and also make it possible to compute instantaneous closure time which can be used to choose between targets when more than one is detected.*

A disadvantage of the radar as compared to the cooperative systems described is that relative altitude information is not easily acquired. This would mean that evasion would have to be done almost entirely with turns instead of the faster vertical maneuver. Special means could be employed to get approximate altitude data but not without introducing additional complication into the system.

Another disadvantage results from the fact that radar would almost surely have to be mounted in the nose of the aircraft which restricts the angular coverage to the forward hemisphere. Other means would have to be adopted if complete 360° protection were desired.

* The target with the smallest closure time will be the first to "arrive" and therefore must be given first priority.

## Conclusion

From what has been said, one should not draw the conclusion that either cooperative or self-sufficient systems have definite superiority. It is certainly clear that to provide a radar having the necessary capabilities will entail more difficult technical problems than the cooperative systems that have been described. Such a radar would be more complex than those in use today, and whether the additional capability would warrant resulting increased cost remains a moot question.

On the other side of the ledger, while the cooperative approach might look inviting from a technical point of view, it cannot look attractive politically. The problem of trying to get all aircraft fitted with the necessary equipment can well turn out to be more difficult than the technical challenge of the radar problem. It is folly to assume that immediate equipping of all air liners (about 2,000 airplanes) with cooperating systems will solve the problem. The real threat to air liners comes from the other 139,500 aircraft flying, and they are the ones with sales resistance to special-purpose collision prevention devices.

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# Mass Flowmeter Summation System

*A measurement system for total fuel flow in multiengine aircraft, as well as for fuel flow to each engine.*

## Introduction

High rates of fuel consumption in modern aircraft have made necessary accurate fuel flow measurement systems.

The amount of power an engine delivers is dependent on the mass or weight of the fuel which it consumes. Therefore, the mass flow of fuel to engines must be measured in order to operate them at maximum efficiency. From this, a running evaluation of engine operating efficiency through comparison with previous experience data is available. In addition, total remaining flight time may be easily calculated.

In multiengine aircraft, a flowmeter system which will indicate the total mass rate of fuel flow in addition to the individual flow rates is necessary so that the pilot or flight engineer may quickly make computations. This paper describes the development of a summation system employing totalization in conjunction with the true mass type flowmeter.

## Summation Systems

Addition, or summation as it is called in the case of flowmeters, is a very simple computation. However, the military specifications allow only one additional component to be added to existing flowmeter systems. Also, the single-engine indication is expanded in the normal cruising range for the purpose of improving reading accuracy. These requirements make summation difficult.

One approach to this problem which has been evaluated was to locate two electrical transmitters in each flowmeter primary detector. One of these transmitters drives the indicator for the individual engine. The other transmitter provides an output signal to be added in series with that of the transmitters of other engines. The total is then presented on a summation flowmeter indicator. It was found that this method had disadvantages which made it difficult to instrument. Additional wires from the transmitters located in the wings or on the engines of the aircraft had to be carried to the instrument panel, and these wires added weight to the system. A more serious problem was lead capacitance which caused a phase shift in the a.c. voltages being added. A third disadvantage was the necessity of replacing the primary detectors if summation was to be installed in existing aircraft.

The summation flowmeter system described here has overcome these disadvantages by performing the addition entirely in the panel-mounted indicators.

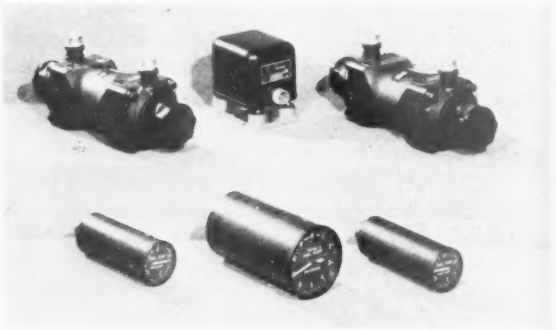

Fig. 1. Summation flowmeter system for two-engine aircraft installation.

## Principle of Operation

### *Summation System*

Summation, as illustrated by a two-engine† summation system shown in Fig. 1, is accomplished by adding a.c. voltages from the individual engine indicators and opposing them with an equal and opposite voltage in the summation or totalizing indicator. Fig. 2 shows a wiring schematic for an eight-engine system. Eight similar transformers with 12-volt secondaries are used for isolation from the 115-volt, 400-cycle line. This is equivalent to 1 volt per 1,000 lbs. per hour for the system described. To obtain correct addition of voltages

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* Aircraft Instrument Advance Engineering, Instrument Department.

† The two-engine system is shown for clarity only. Normally, summation is not installed unless the aircraft has three or more engines.

with the two-slope scale, the 0 to 3,000 lbs. per hour range of the scale is shunted, thereby making the output voltage directly proportional to flow rate. Located in the totalizing indicator is another transformer of similar design, except that its total secondary voltage is 100 volts which, for one volt per 1,000 lbs. per hour, is equivalent to 100,000 lbs. per hour. This voltage is impressed on a linear ten-turn potentiometer. The output of this potentiometer opposes the sum of the voltages from the single-engine indicators. The difference or error signal is then the input to the servoamplifier. The servomotor responds to drive the system to a null indicating the total flow rate. The block diagram for the system is shown by Fig. 3.

The only components of this summation system are, therefore, a totalizing indicator and a power supply per aircraft with an individual engine indicator and flow transmitter for each engine.

### *Flow Rate Primary Detector*

The principle of operation of the primary detector[1] is that of adding angular momentum to the fuel, proportional to mass rate of flow, and then removing this angular momentum by a measurement means.

The flowmeter consists of two identical cylinders and a surrounding housing (Fig. 4) with coincident axes. This housing closely fits the outer diameter of the cylinders. Around the periphery of the circular cross section of the cylinders, at a fixed radius from the center, are a number of equally spaced holes which are accurately parallel to the axes of the cylinders. Fluid moving down the pipe enters the holes in the first cylinder, passes through the holes in the second cylinder, and continues along the fluid pipe line. By driving the upstream cylinder at a constant angular velocity, this fluid is given a velocity at right angles to the direction to fluid flow. This angular velocity constitutes a change of momentum of the fluid which, for constant angular velocity, is directly proportional to the mass of the fluid flowing. The angular momentum is removed while passing through the second cylinder, resulting in torque directly proportional to the mass rate of flow. Restraining springs on the downsteam turbine oppose this torque, causing a deflection proportional to flow rate. To telemeter this deflection to the individual

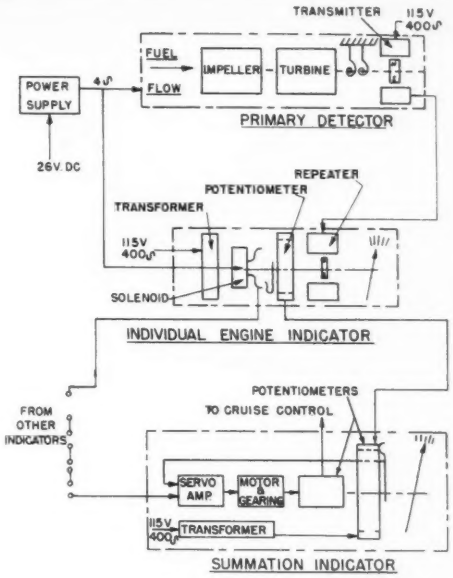


FIG. 3. Summation system block diagram.

engine rate indicators, a second harmonic transmitter* is attached to the turbine, and two springs of different torque gradients are used to restrain it. This permits a two-slope scale on the individual engine indicators allowing greater sensitivity at the low flow rates. A cutaway view of a primary detector is shown in Fig. 5.

### *Individual Engine Flow Rate Indicator*

The indicator of the mass rate of fuel flow to an individual engine repeats the angular position of the second harmonic transmitter in the primary detector. In addition to the index hand for visual indication, the rotor drives the brush arm of a potentiometer. This brush arm makes contact for a short interval to provide a signal for summation and is then released so that the rotor is free of friction loading and continues to indicate accurately. The contacting force is produced by a sole-

* This is a type of synchro-transmitter using a permanent magnet rotor operating on a saturation principle. It requires no leads to the rotor.

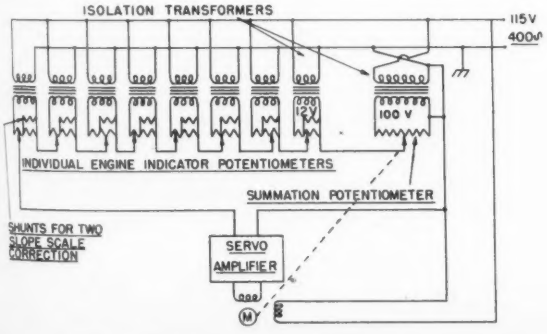


FIG. 2. Summation system wiring schematic.

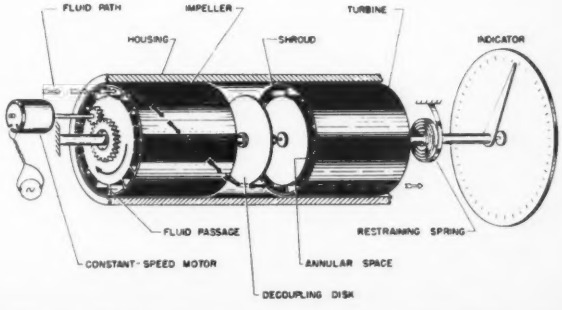


FIG. 4. Flow rate primary detector functional schematic.

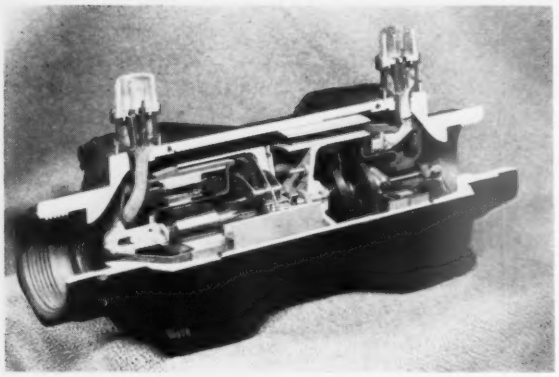

FIG. 5. Flow rate primary detector, cutaway view.

noid which is synchronously operated with the solenoids in the other single-engine indicators.

***Summation Flow Rate Indicator***

The summation indicator provides an indication of the total mass rate of flow to all engines. This indicator consists of a two-pointer multiple revolution indication of flow rate from 0 to 100,000 lbs. per hour. The pointers are positioned by a servodriven gear train which also positions the brush arm of the follow-up potentiometer. Also positioned by the servosystem is a potentiometer to provide a signal proportional to total flow rate suitable for use by a cruise control system, recorders, or flow rate integration.

***Power Supply***

The low-frequency power supply required to drive the impellor in the primary detector is also used to actuate the solenoids in the individual engine rate indicators. This 4-cycle signal desirable for driving the impellors is suitable for operating the solenoids for summation.

## PERFORMANCE

The overall accuracy of the summation system is greater than that which might be expected by adding individual component errors[2] because of two factors: (1) On the basis of normal probability, the total error will be less than the sum of the component errors because of cancellation of errors of opposite sign. (2) Increased accuracy over that obtained by manual addition is obtained because the resolution of the potentiometers in the individual engine indicators is greater than the readability of the 2-in. dials. These factors mean that this summation system takes advantage of the inherent accuracy of the primary detector of mass flow rate.

Representative test data on a development sample system are shown in Fig. 6. Additional characteristics are shown in Table 1.

A sample of this summation system has met all military environmental requirements with several hundred hours of successful flight time.

TABLE 1
Component Characteristics

| | Primary Detector | Individual Engine Ind. | Summation Indicator |
|---|---|---|---|
| Range (p.p.h.) | 0–3,000–12,000 | 0–3,000–12,000 | 0–100,000 |
| Accuracy | | | |
| L.R.* | 1% of point | 10 p.p.h. | 1% of point |
| H.R.† | 2% of point | 20 p.p.h. | |
| Sensitivity (p.p.h.) | | | |
| L.R.* | 2 | 2 | 100 |
| H.R.† | 15 | 20 | |
| Response (sec.) (0 to full scale) | 2 | 1 | 20 |
| Size (in.) | $3^3/_8$, $3^3/_8$, $10^1/_2$ | 2D 5 Lg. | $3^1/_4$D 6 Lg. |
| Weight (lbs.) | $5^1/_2$ | $1^1/_4$ | $2^1/_2$ |

* L.R.—Low range, 0–3,000 lbs. per hour.
† H.R.—High range, 3,000–12,000 lbs. per hour.

## DESIGN

A few of the design features of the system are described in greater detail below. Fig. 7 shows an individual engine indicator assembly. Fig. 8 shows a view of the summation indicator.

***(1) Voltage Addition***

Addition of a.c. voltages requires accurate phasing so that the vector sum of the individual voltages may be opposed by a single voltage of opposite phase. Accurate phasing is also important in order to minimize quadrature voltage which saturates the servoamplifier causing low sensitivity. This was accomplished by constructing the isolation transformers on toroidal cores, thus eliminating variable air gaps. Another cause of phase shift in a voltage-adding system of this type is leakage capacitance, allowing out-of-phase currents to flow in the circuit. Capacitance between the primary and the secondary isolation transformers was minimized by winding the primary on 180 deg. of the toroid and the secondary on the remaining 180 deg. Further reduction was obtained by separating the windings from the core by nonmetallic spacers. Voltage and frequency variations do not cause adding errors because the transformers are all excited from the same source.

***(2) Potentiometer***

The potentiometers in the single-engine indicators are of conventional design except that a tap is brought

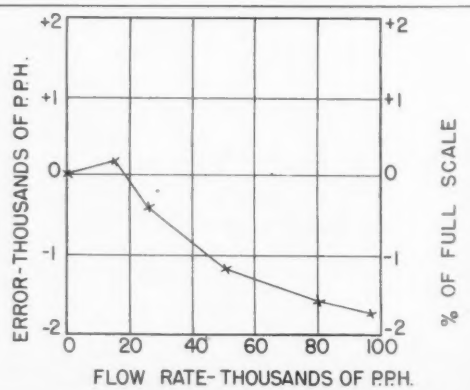


FIG. 6. Summation flowmeter accuracy.

out at the change in slope point at 3,000 lbs. per hour and a shunt is placed across the lower scale in order to make the output voltage linear with flow rate. This shunt is adjustable, thereby making the design of the potentiometer less critical. Total resistance or resistance changes with temperature of the potentiometer are unimportant inasmuch as the system is a voltage dividing device. To drive the brush of this potentiometer, only a very small torque was available from the individual engine indicators. Even the lowest torque-driven potentiometers on the market required one hundred times the torque allowable. To overcome this problem, the brush of the potentiometer is intermittently contacted on the potentiometer by a solenoid. This completes the circuit for approximately half the cycle and then opens it for half a cycle, thereby letting the brush and indicator be free to reposition itself. At a frequency of 4 cycles or greater, this tapping occurs without any visible change in the indicator reading even during rapid changes in flow rate. The solenoid, which actuates the brush against the potentiometer, consists of a stationary permanent magnet and a moving coil on a light aluminum shell. Power is obtained from the 4-cycle constant frequency supply which drives the impellers in the primary detectors. These solenoids consume about 1 watt of power, and, to insure long life and reliability, bearings are jeweled to reduce friction and to eliminate the need for lubrication.

The brush of the potentiometer is a wire of precious alloy shaped to have the proper flexibility, normal contact pressure, and wear requirements.

### (3) *Holding Circuit*

While the solenoid is in the back position and the indicator is free to reposition itself, the amplifier input circuit is normally open, allowing spurious noise signals to cause an erroneous servoposition. To eliminate this, contacts in each indicator short the amplifier just prior to the brush leaving the potentiometer, thereby holding the totalizing indicator until the next signal is obtained. A 40 per cent "on" signal has been found sufficient to meet the 20-sec. response from 0 to 100,000 lbs. per hour in the totalizing indicator.

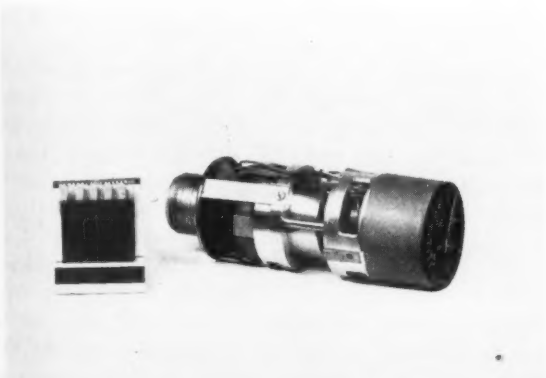

FIG. 7. Individual engine flow rate indicator.

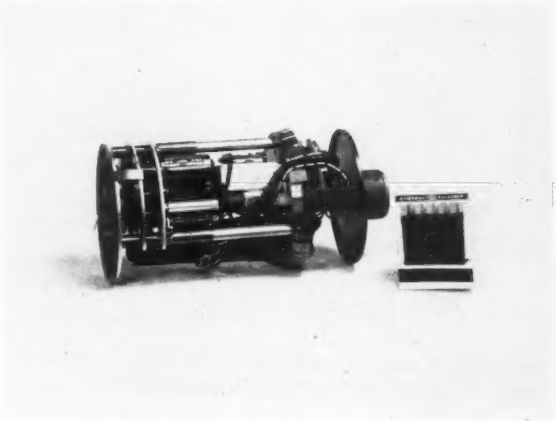

FIG. 8. Summation flow rate indicator.

### (4) *Integral Amplifier*

As silicon transistors become available, integral all-ambient amplifiers are becoming the rule rather than the exception. At the time of this development, it was necessary to accomplish this with subminiature vacuum tubes. Later models will incorporate transistor elements.

A maximum allowable temperature within the instrument of 100°C. is required because of luminescent dial paint deterioration. To meet a 71°C. ambient, the internal rise therefore is limited to 30°C. This is possible with an amplifier of only three tubes consisting of a voltage amplifier type 5719 and a pair of 5718's in push pull for power output to the servomotor.

The motor provides phase discrimination, and silicon diodes provide rectification for the plate supply voltage. To ensure good heat dissipation, the tubes are mounted on an aluminum plate backed by a phosphor bronze sheet which is flared to contact the outer case. In a production design, the electronic component will be detachable as a plug-in unit.

## CONCLUSIONS

The mass flowmeter summation system described is a practical measurement means for the total fuel flow in multiengine aircraft as well as the fuel flow to each engine. Summation for two to eight engines has been demonstrated as being completely automatic requiring no adjustment or calibration in the aircraft.

The principles used in this summation flowmeter may be applied in other aircraft systems. In particular, output signals may be obtained from low-torque indicators by use of this technique where conventional servomechanisms could not be used because of size and complexity.

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[2] Wrobel, H. T., and Buckley, R. F., *Fuel Mass Flowmeter Meets Needs of Aircraft Operation*, Aviation Age, Vol. 20, No. 6, p. 136, December, 1953.

[3] Chow, C. K., *Contactor Servomechanisms Employing Sampled Data*, AIEE Transactions, Vol. 11, p. 51, March, 1954.

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Civil Aeronautics Administration

# Air Traffic Facts

*Future air traffic is considered in terms of population-growth and hub-system statistics, so that these facts may be applied by the CAA to the role and mission of air transportation in the United States.*

## Background

### *Introduction*

Fundamental and ranking first among air traffic facts are ones that deal with the numbers, economic welfare, and travel habits of the great American public. The Civil Aeronautics Administration knows this is true because of its own research into the background, design, development, and operational use of air traffic facts. CAA's operations research program on air traffic facts is well along. Substantial work has been completed, and the results have been made known to the public and the industry in a series of booklets beginning with *Economic Character of Communities* and ending, so far, with two publications—namely, *Federal Airways Plan* and *VFR Air Traffic and Its IFR Relationship*. Our work has taught us in CAA always to remember and to apply air traffic facts in accordance with air transportation's role and mission in the United States—i.e., John Q. Citizen's realized needs for survival protection and the air movement of himself and his belongings from one location to another.

### *Population*

We 165 million Americans are a prolific people. In less than 50 years we have doubled our number, and, by the year 2,000, it is likely that the United States will have a population of more than 300 million. The Census Bureau predictions for 1960 range from 176 to 179 million and between 186 and 193 million by 1965. Do you realize that population growth alone guarantees at least a 10 per cent gain in air traffic by 1965 and a 100 per cent one by 2000? We all know these will be minimum, for air transportation's rate of growth has and will exceed the one for population.

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* Planning Officer, Office of the Assistant Administrator for Planning, Research, and Development.

### *Economic Welfare*

We 165 million are a productive people. Since 1946, the American economy has been in a state of vigorous expansion. Gross national product (GNP), which measures the market value of national output, rose from $209 billion in 1946 to $357 billion in 1954, while national income (which is the flow of labor and property income generated in current production) rose from $180 billion to $300 billion during the same period.

In addition to a relatively high level of security expenditures, there are many strong underlying forces, such as the high level in plant investment, which provide the basis for a long-term economic expansion. Projections indicate a gross national product of $436 billion in 1960 and $535 billion by 1965. These translate into a 50 per cent GNP increase in the next 10 years, and air traffic has and will grow faster than the economy as a whole. Furthermore, the increase in real per capita income together with the sharp jump in the number of relatively well-to-do families imply that a growth industry, such as air transportation, will continue to develop at a rate above the economy's average one.

### *Travel*

Historically, the volume and amount spent for transportation services has been closely correlated with our level of economic activity. Table 1 indicates that, between 1946 and 1954, domestic intercity travel expenditures approximated 5 to 6 per cent of total gross national product with the proportion spent on travel increasing at a slightly faster rate than GNP.

We 165 million Americans are travel happy and do more of it each year. Total intercity travel has grown faster than both population and the GNP, but growth has been limited to private automobiles and the air lines. Despite the amazing growth of air-line passenger traffic, there is still plenty of room for growth—in 1954,

TABLE 1
Relation of Domestic Travel Expenditures to Gross National Product, 1946–1954*

| Year | Gross National Product (Billions) | Domestic Travel Expenditures (Billions) | Per Cent of GNP | Total Intercity Passenger-Miles (Billions) |
|---|---|---|---|---|
| 1946 | $209.2 | $10.7 | 5.1 | 344.6 |
| 1947 | 232.2 | 12.4 | 5.3 | 342.9 |
| 1948 | 257.3 | 13.9 | 5.4 | 352.2 |
| 1949 | 257.3 | 15.0 | 5.8 | 375.5 |
| 1950 | 285.1 | 16.0 | 5.6 | 393.3 |
| 1951 | 328.2 | 19.3 | 5.9 | 441.8 |
| 1952 | 346.1 | 20.8 | 6.0 | 465.0 |
| 1953 | 364.9 | 22.2 | 6.1 | 479.3 |
| 1954 | 357.1 | 22.7 | 6.4 | 501.7 |

* Source: Economic Report of the President, January, 1955; CAB and ICC Statistics.

air was only 3.3 per cent of the total intercity travel market and 28.5 per cent of the common carrier intercity travel market.

### *Role of Population and Traffic*

The 165 million Americans within the continental United States are clustered in a relatively few locations rather than evenly distributed throughout its 3 million square-mile area. The most important clusters are the 172 metropolitan areas, which have a "corner" on any and all types of activity.

The 1940–1950 population increase of over 19 million and the 14.5 per cent rate both confirm the upward trend established in the 1910–1930 period. The severe slackening of population growth during the thirties represented a deviation from the long-term trend due to unfavorable economic conditions. Continuation of this long-term trend, at a rate somewhat comparable to the one for 1940–1950, can be expected during the fifties, with the bulk of the increase concentrated within the standard metropolitan areas.

The dominant position of these 172 communities in the United States can only be indicated by percentage comparisons, for they are the focal points for our entire economic system. Activities outside their boundaries are interwoven and are dependent upon the ones within these areas. To illustrate their economic importance, these areas have: (1) more than one out of every two people; (2) four fifths of the 1940–1950 population increase; (3) over 60 per cent of the retail and nearly 90 per cent of the wholesale sales; (4) nearly all of the important concentrations of civil aviation and most of the major military bases.

Population size sets air traffic perimeters—no small metropolitan area has the air traffic potential of Cleveland, Seattle, or Miami. It is worth noting that nearly all of the 1940–1950 population increase occurred within the metropolitan areas, and the same is even more evident in the fifth decade of the twentieth century.

The location of the large standard metropolitan areas within the continental United States, particularly the ones with a population of 1 million or more, determined the basic en route pattern. The pattern can be likened to a series of wheels. The large hubs are communities like New York, Chicago, Los Angeles, San Francisco, and Washington which are connected by wheel spokes to lesser hubs and rim points. High-density traffic moves between hubs; significant volume occurs between a large hub and a lesser one. The volume for pairs of small cities is relatively unimportant. The concentration of activity around a few hubs and in distances of less than 500 miles is the trademark of the air traffic pattern.

### *Role of Economic Character*

Economic character objectively defines the manner in which a community earns its livelihood. Criteria used were wholesale sales per capita and the percentage of the gainfully employed in mining and manufacturing, which are measurements, respectively, of the two most important economic activities in any community—namely, trade and industry. Of the four basic types of communities established, marketing centers and institutionals have the highest air traffic potential with balanced in the middle and industrial lowest.

### *Summary*

Three basic population/air traffic relationships exist: (1) The distribution and concentration of population within the continental United States establish the pattern and control the apportionment of air traffic in and between communities. (2) A community's population size and economic character fix its volume of terminal air traffic. (3) The flow of air traffic between pairs of communities varies directly with the size of their population product and inversely with the distance between them when due allowance is made for such secondary factors as (a) differences in the air/surface distance ratio, (b) minimum effective distance for the present-day aircraft, (c) the economic character of each community in a pair, and (d) the density of communities within a geographic area.

It is evident that the geographic distribution of the large metropolitan areas has determined the air-line passenger pattern within the United States. Will the present pattern hold true for the future? The answer is an unqualified yes, for the population distribution within the United States, as disclosed by the 1950 census, is similar to the ones for previous years with the only significant change being an intensification of the population trends established in prior years. Probably the outstanding facts in the 1950 census were the continued urbanization of the United States and the concentration of the 1940–1950 population growth within the standard metropolitan area.

## TERMINAL AIR TRAFFIC

### *Types of Data*

There are six types of terminal air traffic data required if one is to have a complete story on all users—

i.e., VFR and IFR facts on air commerce, general aviation, and military air traffic. CAA has complete and excellent civil air traffic facts. The information would be more complete if the military had comparable data on its activities.

Several excellent yardsticks exist to measure the volume of air traffic in a community. Enplaned air-line passengers and air carrier departures are indexes of primary importance in air commerce traffic; the number of airworthy based aircraft in a community indicates its relative volume of general aviation (all civil air transportation except air commerce); the number of aircraft departures measures aeronautical activity at a military air base; instrument approaches show the volume of instrument flight activity by location. Each index has its use, but enplaned air-line passengers are the common denominator that best interprets a community's air traffic, present and potential, in terms of community size, character, geography, and aviation's role in its livelihood.

### *Air Traffic Hubs*

Type of hub is defined in terms of enplaned air-line passengers. The communities have been classified as large, medium, small, and nonhubs. Table 2 shows the method of classification used.

The hub designation for a community has a continuity through time. While changes do occur, the degree of change is too little to be significant. Most changes occur among the minimum small hubs, but even here the number is small.

### *Hubs and Traffic*

All types of air commerce traffic are concentrated in the air traffic hubs. In fiscal year 1955, the hubs had 79 per cent of the domestic air carrier departures, 95 per cent of the passengers, 96 per cent of the mail, and 97 per cent of the cargo. Significant concentrations do not, as a rule, occur in nonhub locations.

I think it well to show you how big and important general aviation actually is. When compared on an hours-flown basis with air commerce, general aviation is nearly three times larger. Eusiness flying alone had more hours flown than United States air carriers. This does not mean, of course, that an hour flown on a Navion equals one on a DC-7, but it does mean that air traffic facts on general aviation are necessary too.

The air traffic hub system holds for and well describes any significant terminal concentrations of general aviation. Less than ten active general aviation aircraft is typical at a nonhub. Exceptions do occur, and it is usually when a nonhub like San Jose has a contiguous boundary with a "giant" among air traffic hubs like the San Francisco-Oakland metropolitan area.

Significant concentrations of peak-day VFR military aircraft departures are, as a rule, found only within the air traffic hub system. For example, a typical high-peak day for a large hub was 97 departures as compared to 83 for a medium, 46 for a small, and 21 for a nonhub. The diminution of military traffic concentrations with the decline in hub classification holds also if one speaks in terms of averages or maximums.

TABLE 2

| Type of Hub | Per Cent of Total Enplaned Passengers in the U.S. |
|---|---|
| Large | 1.00 or more |
| Medium | 0.25 to 0.99 |
| Small | 0.05 to 0.24 |
| Nonhub | Less than 0.05 |

### *Application*

The CAA develops air traffic facts so they may be used. Specifically, the CAA's Planning Standard for Public Airports relates the airport-service type (Intercontinental-Continental-Express-Trunk) to hub-type of the community served and measures aeronautical demand for airport facilities in terms of enplaned passengers and active aircraft. Again, CAA's Airway Planning Standard #1 primarily determines the need for Federal Airport Traffic Control and Electronic/Visual Terminal Aids by the volume of air traffic. The hub concept permeates our terminal establishment planning, and we thus achieve maximum aid at a minimum outlay to terminal air transportation that is consistent with traffic density requiring federal control for safety and first-rate air traffic control. For example, only 19 airports with CAA traffic control serve nonhub locations, and their F. Y. 1955 average number of air carrier/itinerant aircraft operations was 36,162—far less than the level of activity at an airport serving an air traffic hub. The average number of annual instrument approaches at a nonhub airport in F. Y. 1955 was only 977 as compared with 6,489 at a large hub. No doubt can exist that IFR terminal air transportation problems are centralized on a relatively few airports serving large and medium hubs.

## En Route Air Traffic

### *Types of Data*

There also are six types of terminal air traffic data required for a complete air traffic fact picture of en route air transportation. The six are VFR and IFR data for air commerce, general aviation, and military. CAA has complete, excellent data on all IFR en route air traffic—unique, too, because similar facts are not available on a nationwide, recurring basis for other forms of transportation. The VFR en route air traffic facts are sufficient for general aviation and military and are excellent for air commerce. IFR data serve well as an indicator of VFR flying also.

The CAA publication, *Air Route Traffic Survey*, and its related tabulations contain actual IFR peak-hour and peak-day counts of aircraft for each airway segment by type of user. We know, for example, that the El Paso-Salt Flat segment of the Green 5 airway had 99 IFR aircraft on the peak day of the El Paso

Air Route Traffic Control Center and that 12 of the 99 were air carrier, 85 military, and two general aviation. Furthermore, these air traffic facts tell us that New York - Washington exchanged 132 IFR nonstop flights on their peak day—this IFR origin/destination information is also available for each pair of places having traffic with each other.

### *Origin/Destination*

Some 273 pairs of communities exchanged ten or more IFR aircraft departures on their peak day of 1954; other pairs exchanging less than ten flights were not high-density pairs. The distribution of these pairs (see table 3) shows the dominant role of the hub system; only three pairs were nonhub to nonhub, and 27 more had one community a hub and the other a nonhub. Noteworthy is the fact that the 5,904 departures between these 273 pairs account for 51.1 per cent of the total.

### *Traffic Flow*

Actual counts of IFR aircraft for each airway segment and significant direct route, by type of user, has enabled the CAA to define objectively such terms as "high," "average," "minimum," and "low" volume of en route IFR air traffic in terms of aircraft. For example, a "high" volume of IFR means a route segment with a peak day count of 70 or more IFR aircraft (peak-hour count of ten or more is usual), while "low" means 10–19. En route traffic facts make it possible for CAA to fit the airway system to traffic, present and potential.

### *Application*

The use of en route air traffic facts in CAA's planning and programming is everywhere, but it is most evident now in the Federal Airway Program. CAA's Airway Planning Standard #2 and the Federal Airway Plan are prime examples of facts in action.

## Air Traffic Forecasts

### *Domestic Passengers*

Passengers are the best index of community air commerce activity and serve to define the air traffic hub system used in CAA terminal area planning. Airline passenger traffic and forecasts have an important role in the preparation of the National Airport Plan and serve as a basis for estimating future CAA and industry requirements and activity.

The CAA believes that a 1960 forecast of 55 million passengers and a 1965 forecast of 70 million passengers are realistic ones for the domestic air lines. The 1960 forecast is a projection based on the rate of growth between 1950 and 1954 of 3.8 million passengers each year. The 1965 goal of 70 million will mean an increase of 3 million passengers each year for the 1961–1965 period. If helicopters effectively develop the true short-haul market, these forecasts may be too low. Accordingly, these estimates will be periodically reviewed in the light of continuing developments.

Table 3
Dual Pairs with Significant IFR Traffic

| Hub Types of Communities in Each Pair | | Number Pairs | Departures Both Ways |
|---|---|---|---|
| Large-Large | | 50 | 1,602 |
| Large-Medium | | 75 | 1,850 |
| Large-Small | | 46 | 770 |
| Large-Nonhub | | 12 | 245 |
| Large-Territorial | | 4 | 90 |
| Large-Foreign | | 3 | 44 |
| | Subtotal | 190 | 4,601 |
| Medium-Medium | | 18 | 300 |
| Medium-Small | | 29 | 420 |
| Medium-Nonhub | | 7 | 105 |
| | Subtotal | 54 | 825 |
| Small-Small | | 13 | 172 |
| Small-Nonhub | | 8 | 112 |
| | Subtotal | 21 | 284 |
| Nonhub-Nonhub | | 3 | 38 |
| Territorial-Territorial | | 5 | 156 |
| | Total | 273 | 5,904 |

### *Business Flying*

Business flying is by far the major segment of general aviation flight activity and accounted for 45 per cent of all general aviation flying hours in 1954. It covers flying by companies or individuals in carrying out in their own aircraft the operations of their given enterprises or professions.

Business flying has been growing faster than any other category, and this growth is expected to continue throughout the next decade. Anticipated developments in aircraft design plus a number of significant long-range trends in the American economy all point to a further healthy expansion in business transportation by general aviation aircraft.

Among the long-range trends favorable to business flying growth are continued industrial dispersion, the general optimism of businessmen generated by the continuation of high profit levels, sectional competition, and the realization by companies and corporations that they can keep travel time of high-salaried executives at a minimum by air travel. The convenience and flexibility of travel permitted by a company-owned plane are other attractive features. There is also the element of prestige attached to aircraft ownership as tangible evidence that a firm is receptive to the most modern and up-to-the-minute ideas in transportation as well as their own operations.

For all these reasons, it is estimated that business flying will climb to 5.7 million hours by 1960, an increase of 1.8 million hours (46 per cent) over 1954. By 1965, business flying should total 7.2 million hours, almost double the 1953 volume.

### *Instrument Approaches*

Instrument approaches are the primary criterion for the establishment and discontinuance of all CAA terminal air traffic devices other than tower service and an indicator of en route activity as well.

Air carrier aircraft have accounted for the bulk of all instrument approaches year after year, but their role has been a declining one; air carrier aircraft made only two out of three instrument approaches in 1954 as compared with four out of five in 1946. This proportionate decline in air carrier activity was offset by an increase in military instrument approaches. Only minor fluctuation occurred in the proportion of the total attributed to general aviation aircraft.

In 1954, total instrument approaches were 146.2 per cent above 1948—an average annual increase of 24 per cent. This rate was significantly higher than the average annual rate of 11.5 per cent for 1951–1954 and comparable to the 20.1 per cent for 1953–1954. These variations occurred primarily because of the unusual growth pattern of instrument approach activity. Wide fluctuations by military and general aviation aircraft have been somewhat offset by the more normal growth pattern of the dominant air carrier activity.

Thus, on the assumption that, in the future, aircraft will make greater use of the airways facilities, a 1960 forecast of 900,000 instrument approaches by all users appears to be reasonable. We believe that, by 1965, the total instrument approaches will be from 1,000,000 to 1,200,000.

## Conclusion

We in CAA believe in and use all air traffic facts available and recommend that facts replace opinions, where possible, and that always facts become the basis for well-informed opinions. May I suggest that we go forward with facts.


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*Problems involved in accurate translation of defined weather conditions into pilot experience, in view of the varying sensitivity of aircraft to weather at different times.*

# All-Weather Flight Concern of the Pilot and Weather Forecaster

James K. Thompson*
Wright Air Development Center

PILOTS and weather forecasters are both concerned with the definition of weather conditions to be experienced during a given flight. Although some forecasters have been pilots for many years, the forecaster is still unable to describe the experience of a pilot while operating a particular aircraft in the defined weather. This difficulty is not so much a result of an inability to forecast weather conditions as it is a result of an inability to translate the defined weather into pilot experience in the given aircraft. Aircraft sensitivity to weather is not always the same even for a given aircraft during a given flight. The difficulty is further complicated by the forecaster's indiscriminate use of pilot reports from the many different types of aircraft that travel the airways. This variation of the aircraft sensitivity and engineering methods for defining the sensitivity are the subjects of this paper. Considerable progress can be expected in the pilot-forecaster communication problem if engineering methods are adapted to the weather problem in such a manner as to provide a basis for translating weather conditions to pilot experience.

Fig. 1 illustrates the communication problem between pilots and weather forecasters and shows the problem area where methods for translation are required. Note the fighter aircraft in the thunderstorm with rain, ice, turbulence, snow, and lightning. The forecaster receives a flow of data from the storm area while the pilot receives a sensation of aircraft reaction to environmental conditions. The forecaster also receives pilot reports from other aircraft. He attempts to translate both the data and the pilot reports into a description of the experience of the next pilot to operate aircraft in the weather. There is a two-way flow of information between the pilot and forecaster, therefore, and the communication between these two is doubly ineffective if the translation is not accurate.

FIG. 1.

Fig. 1 also shows a flow of information to the pilot from Flight and All-Weather Testing. This organization conducts what is called the Fifth Phase of the Air Force Research and Development flight test program. The results of these tests are the pilot's operating instructions for flight in all weather and the Air Force qualification of a new type of aircraft for operation in the various degrees of extreme weather such as rain, ice, turbulence, extreme temperatures, and low visibility. There is also a continuing addition to the pilot's operating instructions as a result of operational experience. For those who are concerned with the operation of commercial aircraft, there is a somewhat similar flow of information from tests conducted by the manufacturer, Civil Aeronautics Administration, and the operating organization. In all instances, the pilot is provided with detailed instructions for operating each type of aircraft in weather.

Presented at the Meteorology Session, 24th Annual Meeting, IAS, N.Y., Jan. 23–26, 1956.

* Technical Adviser, Directorate of Flight and All-Weather Testing.

Further consideration of Fig. 1 indicates the lack of a flow of environmental test information about individual aircraft peculiarities from the test organizations to the forecaster. Although the flight test reports are made available to the weather service, the reports are engineering reports which are written to the pilot or to other engineers, and there is no flow of information for the specific use of the forecaster. The establishment of this type of information channel is an essential factor in the solution of translation and communication problems between the pilot and forecaster.

One of the first steps in the solution of the communication problem requires that the forecaster understand the pilot's use of air-speed schedules. Fig. 2 shows air-speed schedules as a function of altitude for a typical fighter-type aircraft. The ordinate is flight altitude in thousands of feet while the abscissa is what we call calibrated air speed in knots. (Calibrated air speed is indicated air speed corrected for instrument and installation errors.) If this aircraft is required to hold over a given station, the pilot will use the approximate speeds indicated by the curve for maximum endurance. During the climb following a take-off, the pilot will operate the aircraft so that speeds will vary according to schedule indicated for the climb condition, unless exceptional circumstances require use of the afterburner and the schedule shown for maximum climb. The speeds generally used for the cruise condition are shown by the curve for maximum range, and the speeds for descent by the curve for descent. Even if the discussion is limited to the climb, cruise, and descent conditions for this one aircraft, there is still a variation of about 100 knots. This variation is sufficient to cause serious confusion between pilots and forecasters when the communication concerns turbulence or icing conditions. It is even greater when the variations caused by the use of many aircraft are considered.

Fig. 3 shows the importance of speed and aircraft weight when the flight is to be conducted in turbulent air and also how the air-speed schedules can be used to solve a part of the pilot-forecaster communication

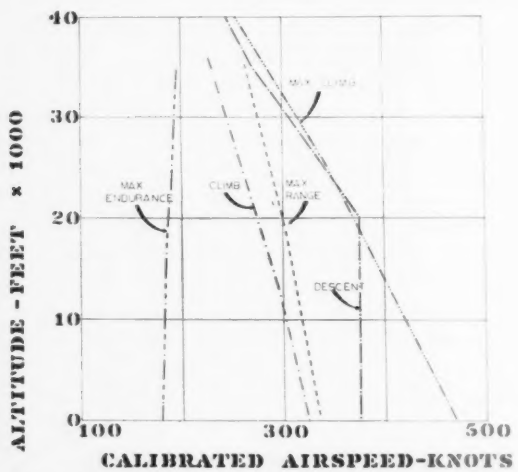


FIG. 2. Air-speed, altitude schedules for a typical fighter aircraft.

$$\frac{\Delta N}{U_{de}} = \frac{S \rho_0 \frac{dC_L}{d\alpha}}{2W} V_e K_g$$

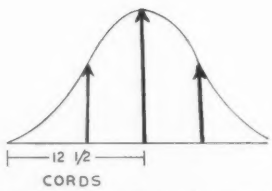


FIG. 3. Turbulence intensity factor (standard gust equation).

problem. The figure shows the equation used by aeronautical engineers to measure or calculate the gust loads caused by atmospheric turbulence. The value $\Delta N$ is the dimensionless measure of the acceleration which results when an aircraft flies through a gust having the magnitude equivalent to $U_{de}$. The ratio, $\Delta N/U_{de}$, is the gust factor which defines the relation of the feel of the turbulence to the magnitude of the gust velocities. The other symbols shown in the equation are defined as follows:

| | | |
|---|---|---|
| $S$ | = wing area | ft.$^2$ |
| $\rho_0$ | = air density at sea level | slugs/ft.$^3$ |
| $dc_L/d\alpha$ | = slope of lift curve | per rad. |
| $W$ | = airplane weight | lbs. |
| $V_e$ | = equivalent air speed | ft./sec. |
| $K_g$ | = gust alleviation factor | dimensionless |

The significance of the equation shown in Fig. 3 is apparent when we consider that the pilot reports turbulence intensity as a result of his experience of "$\Delta N$" while the forecaster tries to forecast gust velocity. For a given aircraft and gust situation, the equation shows that the acceleration is directly related to air speed and inversely related to aircraft wing loading. These factors change the ratio of $\Delta N/U_{de}$ considerably and cause translation and communication difficulties between the pilot and forecaster. Both the forecaster and the pilot usually express interest in the meaning of the derived gust velocity "$U_{de}$." The derived gust velocity is a result of years of experience by aircraft engineers in connection with gust load problems. The engineer has found that the aircraft responds mainly to gusts of a given dimension and direction. Only the vertical components of gusts having distances of 5 to 50 chord lengths from zero to maximum velocity yield significant gust accelerations, and the larger portion of these accelerations are associated with gust distances of the order of $12^1/_2$ chord lengths. They have accepted a standard gust as a basis for gust calculations. This gust is illustrated in Fig. 3. It is a vertical gust and has a distance of $12^1/_2$ chord lengths to peak velocity. The gust velocity varies according to what we call a "one minus cosine" shape and changes with altitude according to the density ratio, so that it compares to true gust velocities

in the same general manner that equivalent air speed compares with true air speed. Although arbitrary, the concept of the derived gust velocity allows a practical solution to the problems of comparing the gust experience of the various aircraft and of predicting the gust experience of new aircraft. It will also solve a part of the pilot forecaster communication problem, for it is a basis for the translation of turbulence information.

Fig. 4 shows the result of an application of the gust equation to the air-speed schedules of the fighter aircraft. In this figure, the abscissa is plotted in terms of the turbulence intensity factor "$\Delta N/U_{de}$" instead of calibrated air speed. The use of the figure can be illustrated if we assume, for example, that the mean derived gust velocity is 10 ft. per sec. during all parts of a given flight. In this instance the pilot will sense a mean $\Delta N$ of $0.35_g$ to $0.3_g$ in the climb condition, $0.4_g$ to $0.35_g$ in the cruise condition (maximum range), and about $0.5_g$ in the descent condition. The pilot would report light turbulence during the climb, light-to-moderate turbulence during the cruise condition, and moderate turbulence during the descent condition. Since we assumed that the turbulence intensity was actually constant, the reports are contrary to fact unless the reports are converted to derived gust velocity by use of the gust factor. If the forecaster and the pilot are to speak the same language, therefore, these differences must be considered.

There is one more step to the communication aspects of the turbulence problem. Since the forecaster must think in terms of gust velocity and speak in terms of acceleration, he needs a readily available method to complete the translation. Fig. 5 shows this translation method in terms of the relation between actual and reported turbulence and the turbulence intensity factor. The ordinate in this figure is normal acceleration at the center of gravity location and shows, for the particular aircraft that reported, intensities of light, moderate, heavy, or severe turbulence occur if the accelerations are between $0.2_g$ to $0.4_g$, $0.4_g$ to $0.6_g$, $0.6_g$ to $0.8_g$, or greater than $0.8_g$, respectively. It can be used to establish the dimensions of gust velocities when pilot reports are available from the particular aircraft or to forecast pilot experience from meteorological data. It completes the translation aspects of the pilot-forecaster communication problem when turbulence is the subject of the communication.

The variations of speed for the typical fighter aircraft have an important effect on the aircraft icing problem. Fig. 6 shows critical ambient air temperatures for aircraft icing as a function of the altitude air-speed schedules. At the 10,000-ft. altitudes, for example, the figure shows no icing during holding operations if temperatures are warmer than −2°C., during the climb if temperatures are warmer than −6°C., and during the descent if temperatures are warmer than −8°C. Although there is little difference in the speed effects at high altitudes for this aircraft, there are significant differences at the lower icing

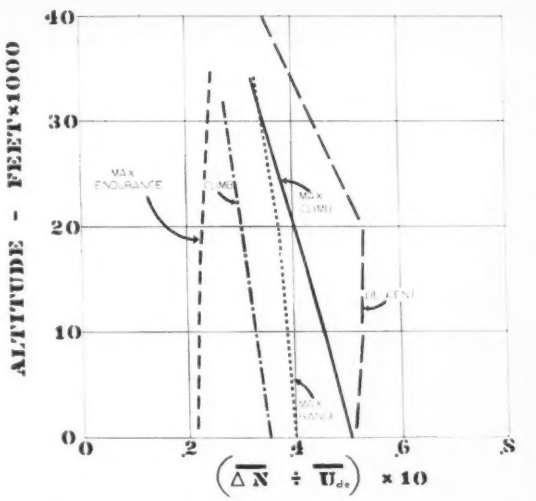


FIG. 4. Turbulence intensity factor for typical fighter aircraft schedule.

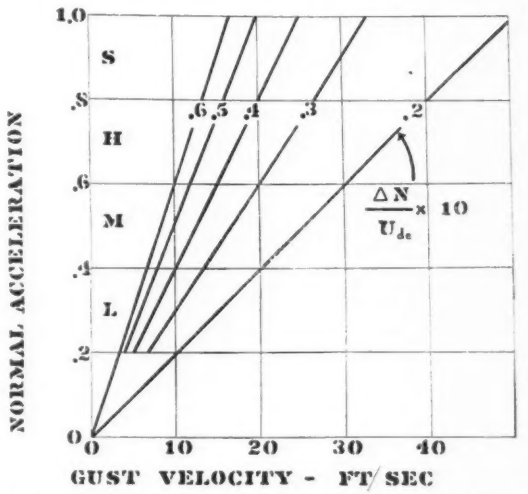


FIG. 5. Relation between actual and reported turbulence intensity.

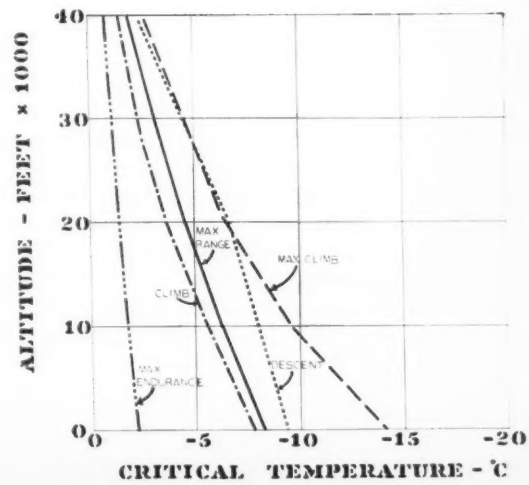


FIG. 6. Icing limits for a typical fighter aircraft.

| DESCRIPTIVE TERMINOLOGY | AIRCRAFT PERFORMANCE CRITERIA | LIQUID WATER CONTENT (GRAMS PER CUBIC METER) | ICE COLLECTION RATES ON SMALL PROBES | |
|---|---|---|---|---|
| | | | INCHES PER 10 MILES | MILES PER $\sqrt{2}$ INCH |
| TRACE | BARELY PERCEPTIBLE ICE FORMATIONS ON UNHEATED AIRCRAFT COMPONENTS. | 0 TO .125 | 0 TO .09 | 56 TO MAXIMUM |
| LIGHT | EVASIVE ACTION UNNECESSARY. (NO PERCEPTIBLE EFFECTS ON PERFORMANCE.) | .125 TO .25 | .09 TO .18 | 28 TO 56 |
| MODERATE | EVASIVE ACTION DESIRABLE. (NOTICEABLE EFFECTS ON PERFORMANCE.) | .25 TO .50 | .18 TO .36 | 14 TO 28 |
| HEAVY | EVENTUAL EVASIVE ACTION NECESSARY. (AIRCRAFT IS UNABLE TO COPE WITH ICING SITUATION AND EXTENDED OPERATION IS NOT POSSIBLE.) | .50 TO 1.00 | .36 TO .72 | 7 TO 14 |
| SEVERE | IMMEDIATE EVASIVE ACTION IS REQUIRED. (AIRCRAFT USES CLIMB POWER TO HOLD ALTITUDE AND CONTINUED OPERATION IS LIMITED TO A FEW MINUTES.) | 1.00 TO MAXIMUM | .72 TO MAXIMUM | 0 TO 7 |

FIG. 7. Icing severity scales.

altitudes. The pilot-forecaster translation problem requires consideration of these speed effects when aircraft icing is the subject of the communication.

Fig. 6 considers only the aspect of ice or no ice. There is also an icing communication problem in connection with icing severity forecasts. Fig. 7 shows the approximate relation between liquid water content and pilot reports of icing intensity for the typical fighter aircraft. (These values are for common icing and do not consider freezing rain since freezing rain is not a unique problem for this aircraft.) Pilots of this aircraft will report traces of ice or no ice if formations are barely perceptible on aircraft components when liquid water contents are less than 0.125 Gm. per cu.m. and if more than 56 miles of flight are required to collect 1/2 in. of ice on small components. As a further example, the pilot will report severe icing if climb power is required to hold altitude and if liquid water contents are greater than 1.00 Gm. per cu.m. The figure also shows that 1/2 in. of ice can be picked up in less than 7 miles of flight in the severe icing condition.

Although the individual peculiarities vary less with aircraft type for this icing intensity relation than for the icing limit and turbulence intensity relations, there are sufficient differences to require consideration in icing intensity forecasts. This particular basis for transfer is purely a test result although it can be estimated by the experienced engineer.

We have considered the pilot-forecaster translation problems which result when atmospheric turbulence or icing conditions are the subject of the communication. There are other problems that also warrant serious attention. In all cases, however, the translation should be complete so that the pilot and forecaster can speak the same language and so that the desired forecast is available and respected. For instance, a forecast of 1/2 in. of hail is of little value to the pilot, for the hail will occur in one or more of the many thunderstorms and during one period of the storm development. The pilot appreciates this indication of the worst possible condition, but he also needs a forecast of expected experience. His experience has to verify the forecast, or a communication barrier arises.

There are two final questions that must be considered in connection with the pilot-forecaster communication problem: who should accept responsibility for effecting the translation, and who should accept responsibility for establishing the methods of transfer? Those who are pilots know of the pilot workload when flight is in instrument weather conditions. It would appear logical, therefore, to require the forecaster to accomplish the translation. As for the responsibility for establishing the standard methods for translation, no single organization possesses the entire range of experience necessary to that problem, and the adequate solution will result only from a joint effort. It would appear, however, that the weather services should accept the responsibility for pursuing the suggested approaches.

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**Robert T. Hall, MIAS, has been promoted to Sales Manager of the Accessories Division, Thompson Products, Inc. He is a former Secretary-Treasurer of the IAS Cleveland-Akron Section.**

## IAS News

(*Continued from page 25*)

been appointed Professor of The Mechanics of Fluids and Director of the University's Fluid Motion Laboratory.

**H. S. Peterson** (AF), formerly Chief Aerodynamicist, has been promoted to Chief Engineer of East Coast Aeronautics, Inc., Pelham Manor, N.Y.

**Bernard L. Prenovich** (AF), of Yeadon, Pa., has been appointed Senior Engineer with the Blaw Knox Chemical Plant Division, Pittsburgh, on the design of nuclear power plants and chemical plants.

**Coleman Raphael** (M) has joined the Advanced Development Division of Avco Manufacturing Corporation, Stratford, Conn., as Chief of the Applied Mechanics Section. He was formerly a Research Design Specialist at Republic Aviation Corporation, Farmingdale, N.Y.

**Karl H. White, AFIAS, has retired as Chief Design Engineer of the Naval Aircraft Factory, NAMC, Philadelphia, after 24 years with the Navy.**

**W. R. Rhoads** (M), Chief Staff Engineer of the Georgia Division of Lockheed Aircraft Corporation, has been named Director of the nuclear-aircraft test laboratories to be constructed and operated for the Air Force by Lockheed on a large wooded tract near Dawsonville, Ga.

**Alfred Ritter** (M) has been named Supervisor of the Aerophysics Section, Propulsion and Fluid Mechanics Research Department, Armour Research Foundation of Illinois Institute of Technology. He was formerly a Research Engineer in the Propulsion and Fluid Mechanics Research Department.

**Mortimer Rosenbaum** (AF), formerly Chief Project Engineer of Convair's San Diego Division, has been named Assistant Chief Engineer of Convair's Atlas ICBM program.

**W. Waits Smith** (M), Manager of the Aviation Gas Turbine Division in Kansas City, Mo., has been elected a Vice-President of Westinghouse Electric Corporation.

**Harry H. Wallace** (M) has joined The Garrett Corporation as a Sales Engineering Representative in Washington, D.C. He was formerly Sales Manager of the Speed Control Division of Fairchild Engine and Airplane Corporation, St. Augustine, Fla.

## CORPORATE MEMBER NEWS

• **Aerojet-General Corporation. . .** A new plant for pilot production and testing of liquid-propellant rocket engines is under construction in Neosho, Mo., on part of the old Fort Crowder reservation. Authorized by the Air Force under a $9,500,000 facility contract awarded Aerojet, the manufacturing building will be completed late this year and the test facilities soon after. Dan A. Kimball, AMIAS, President of Aerojet-General and former Secretary of the Navy, rode a tractor in the groundbreaking ceremony April 21. Aerojet's other plants are in Azusa and Sacramento, Calif.

• **Airborne Accessories Corporation** announces the new R-4100 series of 26-volt d.c. rotary actuators, which are expected to find numerous aircraft applications because of their compact design with high output and light weight.

• **Airborne Instruments Laboratory, Inc. . . .** The Compagnie Generale de Telegraphie Sans Fil, of Paris, France, and A.I.L. have jointly formed an American company to manufacture and market in the United States electronic products developed in France. The new company, called the Intercontinental Electronics Corporation, will tap the resources of Franco-American electronic know-how with the interchange of knowledge, developments, and products. The C.S.F. and its group have 10,000 employees (one fourth of them engineers) distributed among 18 French electronics companies. Hector R. Skifter, President of A.I.L., is a Director of Intercontinental.

• **Allis-Chalmers Manufacturing Company** has issued a 44-page booklet on *Variable-Speed "Texrope" Drives*. Numerous selection tables are included. Copies may be obtained by writing the company at 1227 S. 70th St., Milwaukee.

• **Aluminum Company of America . . .** A large hydraulic forging press capable of applying a force of 8,000 tons is now in operation at the Vernon (Calif.) works. A smaller, 1,500-ton press started production at the same plant last August. Large aircraft forgings of the close-tolerance, low-draft type will be a principal product of the new hydraulic equipment. The 8,000-ton press, which was built in Germany, is of a four-column, three-cylinder design which makes it possible to operate at 2,700, 5,400, or 8,000 tons of force. Its overall height is 49 ft., of which 33 ft. are above floor level. The press weighs about 750 tons. It can produce forgings 500 sq.in. in area. . . . Two large blimp hangars at the Naval Air Station, Lakehurst, N.J., are being reroofed with corrugated aluminum sheet. The job requires 520,138 lbs. of aluminum.

• **American Steel & Wire Division, United States Steel Corporation . . .** The new rod mill at the Cuyahoga Works, near Cleveland, is believed to have the world's fastest rod-rolling machinery. Four lines of rods are produced simultaneously at more than mile-a-minute speeds. Now in the shakedown stage, this mill is expected to reach its annual capacity rate of production of 450,000 tons before the end of this year. The mill consists of 25 roll stands and is capable of rolling all sizes of rods from a diameter of 0.218 to 1.5 in.

• **Beech Aircraft Corporation** has designed for the Air Force a new multipurpose vehicle for ground power support of jet aircraft. Known as the MA-3, it combines a 225-hp. engine, electrical power, jet-engine starters, and air-conditioning equipment for cabin cooling in a self-contained mobile unit for preflight and ground testing of fighters and bombers. The vehicle also is capable of towing multiengined aircraft on the ground. It weighs 15,700 lbs. and has four-wheel power steering and a four-wheel drive.

• **Boeing Airplane Company . . .** The Wichita Division marked 52 consecutive months of on-schedule jet aircraft production in March. During this period, the company announced, Boeing delivered more than 1,200 B-47 Stratojet medium bombers and rolled out an undisclosed number of B-52 Stratofortresses.

• **Bristol Aero Engines Limited. . .** B. A. Chalmers has been elected a Director and Vice-President. He is Secretary of The

Rohr, world's leading builder of ready-to-install Pow-R-Pax for airplanes, will build the precision Pow-R-Pax for the advanced all-jet Boeing 707 commercial airliner. Currently Rohr is building Pow-R-Pax for many other leading commercial and military planes including Lockheed Super G Constellation, Boeing B-52, Douglas DC-7 and the Convair 440.

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AIRCRAFT CORPORATION
Chula Vista and Riverside, California

Bristol Aeroplane Company of Canada Limited.

• **The Cleveland Pneumatic Tool Company . . .** A new synchronous actuator permitting hydraulic operation into areas exceeding 800°F. is announced by the National Water Lift Company Division in Kalamazoo, Mich. In addition to high-temperature performance, the actuator is said to be capable of accurate positioning and minute synchronization within thousandths of an inch between two or more units operating as a system. The company anticipates numerous applications in aircraft.

• **Douglas Aircraft Company, Inc. . . .** The C-133A turboprop cargo transport made its first flight on April 23 from Long Beach, Calif., to Edwards AFB, where it will undergo flight tests. Designed for the Military Air Transport Service, the giant plane can carry a pay load of 50,000 lbs. 3,500 nautical miles or 100,000 lbs. 1,000 miles. Two C-133A's will be able to haul as much cargo in the same interval of time as five C-124 Globemasters. Almost every vehicle used by the Army Ground Forces can be carried aboard the cargo plane fully assembled. Seats can be installed for 200 troops, or the C-133A can be used as a hospital plane. Four Pratt & Whitney T34 turboprop engines provide power for the huge transport, which has a gross weight of 255,000 lbs. The design useful load is 145,583 lbs. Detail engineering on the C-133A began in February, 1953. . . . The supersonic, bat-winged F4D Skyray is now in service with the U.S. Fleet. The first six Skyray interceptors, manufactured at El Segundo, Calif., were delivered in April after twelve Navy and Marine pilots had logged 600 hours in them during familiarization flights at the Naval Air Test Center, Patuxent River, Md. The small, lightweight jet fighter is designed for all-weather operation from carriers. . . . Douglas has announced orders from eleven air lines for 114 DC-8 jet transports and from twelve air lines for 105 long-range DC-7C's.

• **Edo Corporation** has been elected a member of the Radio Technical Commission for Aeronautics. The company is currently engaged in developing an air-borne loran for use on transoceanic aircraft. William R. Ryan, MIAS, Vice-President for Engineering, has been appointed Edo's delegate to the RTCA Assembly.

• **Fairchild Camera and Instrument Corporation . . .** Richard Hodgson has been named Executive Vice-President by the Board of Directors. He will continue as General Manager of the Reconnaissance Systems Division.

• **Fairchild Engine and Airplane Corporation . . .** Announcing air-line orders for several of the 40-passenger transports, Fairchild Aircraft Division said on April 26 that it will put the Fokker F-27 Friendship into production. The company plans to turn out five planes per month, soon accelerating to ten per month, with the first delivery scheduled for October, 1957. Advertised by Fairchild with a price tag of $540,000, the twin-turboprop F-27 was designed specifically to replace the DC-3. It will cruise at 280 m.p.h., climb 350 ft. per min. with one engine out, and have a range of 2,250 miles. Rolls-Royce Dart engines will be used. The cabin will be pressurized. Fairchild expects the F-27 to prove popular with air lines for short and medium runs and with corporations as an executive transport. . . . The Fairchild Engine Division stated recently that its midget jet engine, the J44, had been certificated by the Civil Aeronautics Administration for use in passenger aircraft. The CAA's approval makes the 1,000-lb.-thrust turbojet available for use in several thrust-augmentation applications now under consideration. Installation as an auxiliary power plant to be used in taking off from high airports is an example. Originally designed as the power plant for a guided missile, the J44 weighs 370 lbs. and delivers 2.6 lbs. of thrust per lb. of engine weight.

**These large wing spars for the Convair F-102A, forged on heavy presses by the Wyman-Gordon Company, save 273 parts, 3,200 rivets, and 100 lbs. of weight in the supersonic interceptor.**

• **Federal Telecommunication Laboratories . . .** The Navy's newest giant aircraft carrier, the 60,000-ton "Saratoga," is the second flat-top to be equipped with a Tacan (tactical air navigation) system and a long-range UHF radio system developed by Federal. Tacan provides the carrier's fighter pilots with constant bearing and distance indications, enabling them to obtain an instantaneous "fix" of their position in relation to the moving ship. The Tacan radio signals fan out in a 360° circle and have a radius of 200 miles. They penetrate to high altitudes. The pilot reads distance in miles and tenths of a mile; the bearing indication is claimed to be accurate within 1°. With his direction and distance from the moving flat-top known at all times, regardless of visibility, the jet pilot can better conserve his limited fuel supply and extend his tactical operating range. Returning home, he can locate the carrier easily in pitch darkness. The UHF radio system provides two-way voice communication between carrier personnel and pilots in the air. The "Saratoga" also uses Federal Telecommunication Laboratories' medium-high-frequency radio system, which handles the automatic transmission of telephone, teleprinter, and facsimile messages between the carrier and other ships or shore stations. The Navy has announced that all three radio systems will be installed as standard equipment on large carriers built in the future.

• **The Firestone Tire & Rubber Company** plans to build a 75,000-ton-capacity plant for the manufacture of styrene at its 1,000-acre petrochemical manufacturing center near Orange, Tex. Scheduled to start operation in 1958, the new plant will produce the styrene required by the Firestone Company for the manufacture of synthetic rubber, according to a company announcement. It will be located adjacent to the company's 40,000-ton-capacity butadiene manufacturing plant, which will be completed next year. At present, Firestone claims to be the nation's largest single producer of synthetic rubber. The company expects to be the first in the rubber industry to produce the principal raw materials from which synthetic rubber is made.

• **The Garrett Corporation . . .** The AiResearch Manufacturing Company has developed an altitude control mechanism so sensitive that it can accurately record a change of altitude as slight as 15 in., according to a company announcement. The response is quicker than one fourth of a second. Development of the new barometric altitude control marks AiResearch's entry into the altimetry field. At sea level, the instrument is accurate enough to sense a change in static pressure when raised 15 in. At 60,000 ft. altitude, it registers a change of 20 ft. In operation, the control senses the variable static pressures and conveys these findings to an automatic pilot for correction of the airplane's flight path. In addition to enabling the autopilot to fly the plane at a constant, given altitude, the new instrument also can be used to control rate of descent. When approaching a runway for landing, it will quickly make the necessary corrections for a proper descent rate, through the automatic pilot control. Sensitivity of the new control is obtained through a sensory bellows operated from a fixed position. A change in pressure against the bellows causes it to expand or contract in proportion to the change. This pressure indication is then converted to an altitude reading by a noncircular gear device. AiResearch engineers believe the new instrument lends itself to development of a highly accurate visual altimeter.

• **General Dynamics Corporation . . .** The Convair Division has begun construction of a $40,000,000 plant near San Diego, Calif., to be used for development and production of the Atlas intercontinental ballistic missile. The new plant will be on a 280-acre site near Sorrento Canyon. It will include an engineering and administration building, a test and computer building, and a manufacturing building. Scheduled for occupancy next year, the plant is expected to employ 6,600 persons by 1958. At present, the Atlas project employs several thousand engineers, technicians, and production workers at the Convair-San Diego plant. . . . The Air Force announced recently that Convair's Fort Worth Division has been selected to develop an air frame for a nuclear-powered airplane. Previously, Convair-Fort Worth has been doing research leading to such a

which way* to measure jet engine performance?

KOLLSMAN PRESSURE RATIO THRUSTMETER
used on Convair's F-102 and McDonnell's F-101

# thrustmeters

to indicate PRESSURE RATIO...to indicate DIFFERENTIAL PRESSURE

*Actual photograph*

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**on components for BOTH TYPES—for Remote or Direct reading**

For over a quarter century, Kollsman has been making precision pressure sensitive mechanisms using displacement type diaphragms. This diaphragm can be called the heart of a thrustmeter pressure indicating system.

Our long experience making displacement type diaphragms guarantees reliable thrustmeters.

Proven Kollsman displacement type diaphragms, when fitted with Kollsman Synchrotels, comprise the transmitters for remote indicating types. Thousands of Synchrotels are now in use in other applications equally demanding of accuracy and durability.

Tailor-made Thrustmeters can be supplied for any engine-airplane combination. Write for complete technical information.

**TYPICAL SYSTEM OPERATIONAL DATA**

1. Accuracy: .015 in 100% of readings at room temperature.
   .025 in 85% of readings at −55°C and +70°C.
   .035 in 15% of readings at −55°C and +70°C.
2. Altitude: No specific limitation.
3. Power: 115V, 400CPS, single phase, 18VA
4. Pressure Ratio Range: 1.2 to 3.4
5. Pressure Ranges (operating):
   $Pt_2$=2 to 50" Hg. Abs.
   $Pt_7$=2.4 to 100" Hg. Abs.
   $Pt_7-Pt_2$=0.4 to 70" Hg.
6. Temperature Range: −55°C to +120°C
7. Weights:
   Transmitter: 2.2 lbs.
   Indicator (including integral amplifier): 1.8 lb.
8. Response: Full Range in 7 seconds.

**The Pressure Ratio System has advantages for indicating optimum climb and cruise throttle setting, whereas the Pressure Differential System has a definite advantage at take-off.*

**Kollsman activities cover these seven fields:**

AIRCRAFT INSTRUMENTS • PRECISION CONTROLS
PRECISION COMPUTORS AND COMPONENTS • OPTICAL COMPONENTS AND SYSTEMS
RADIO COMMUNICATIONS AND NAVIGATION EQUIPMENT • MOTORS AND SYNCHROS
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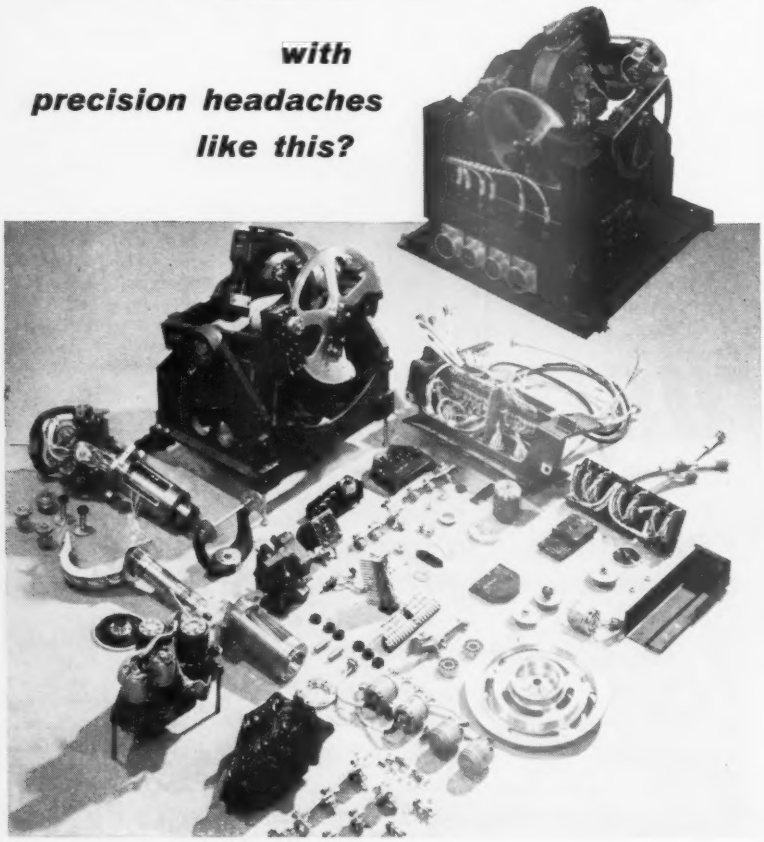
***with precision headaches like this?***



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development. . . . Convair engineers have developed a radar-type rate-of-descent indicator to assist pilots in operating VTO aircraft near the ground. The electronic meter system, which also shows rate of climb, is essentially a continuous-wave doppler radar which uses the ground below the aircraft as a reflecting surface. Since there are ten wave lengths per foot at 10,000 mc., each movement of 1 ft. in altitude changes the length of the radar path by 2 ft., or 20 wave lengths. Thus, each foot per sec. of velocity produces a 20-cycle-per-sec. doppler frequency. The meter, which registers frequency, is accurate right down to zero altitude. It is thus a helpful supplement to the pilot's visual estimate of vertical velocity as he lands a VTO plane such as the XFY-1 Pogo Stick. . . . Sylvan C. Coleman, a partner in the investment firm of E. F. Hutton & Co., New York, has been elected a Director of General Dynamics Corporation.

• **General Electric Company . . .** The J47-25 jet engine is now authorized by the Air Force to be operated up to 1,700 hours before major overhaul—enough time for 35 jet flights around the world. This is the most time between overhauls permitted by the USAF for any axial-flow turbojet or reciprocating engine, according to G-E. It is the second increase in allowable operating time for this engine in the past 6 months. The J47-25 engine, which powers the Boeing B-47 bomber, has a thrust rating of 5,970 lbs. G-E's Aircraft Gas Turbine Division recently announced that it has produced more than 31,000 J47 engines. They have been used in the F-86, B-45, and B-47, and as auxiliary power in the B-36. . . . The G-E Tube Department, Schenectady, N.Y., has issued a 20-page booklet describing microminiature metal-ceramic receiving tubes.

• **General Precision Equipment Corporation . . .** Kearfott Company, Inc., has acquired Bludworth Marine, manufacturer of electronic instruments, as a division.

• **G. M. Giannini & Co., Inc. . . .** J. Murray Wilson has been elected Senior Vice-President and a Director; Aldrich P. Balacek, Vice-President; and Donald H. Putnam, Director.

• **The Goodyear Tire & Rubber Company, Inc. . . .** Goodyear Aircraft Corporation is producing its new missile-guidance system, Atran, for use in the Martin TM-61B Matador missile. An outgrowth of 10 years' experimental work by Goodyear and the Air Research and Development Command, the all-weather navigation device has been tested in firings at Holloman AFB, N.M., during recent months. The Atran instrumentation is installed in the 650-m.p.h. missile in a self-contained "nose package" requiring no controls from an outside source such as a mother plane or ground control station.

• **Jack & Heintz, Inc. . . .** The complete a.c. electric system developed by J&H for the DC-8 jet transport is being manufactured for Douglas Aircraft Company, Inc., with deliveries scheduled for late 1957. J&H will supply approximately 37 components for each DC-8. . . . The company also is producing an a.c. system it developed for Convair's F-102 supersonic in-

# BRANIFF *International* AIRWAYS

*joins the swing to*

# Allison Turbo-Prop Engines

*and Aeroproducts Propellers—*

*to bring you over-400-mile-an-hour luxury travel in Lockheed Electras*

Airlines are going Turbo-Prop in a big way!

Now Braniff International Airways is moving into the jet era—with its purchase of new Lockheed Electras, and has specified Allison Turbo-Prop Engines and Aeroproducts Propellers to power these new luxury airliners.

This matched engine-propeller team is the most advanced aircraft power plant of its type available today. It is backed by the full technical resources and skills of General Motors, plus Allison's experience in building gas turbine engines which have accumulated more than 8 million hours' flight time in military aircraft.

The new luxurious Allison-powered Lockheed Electras will cruise at over 400 miles an hour, bringing jet-age performance on both non-stop and multi-stop operations between the major traffic centers on Braniff's domestic and international routes.

From its beginning, with one airplane flying between Tulsa and Oklahoma City 28 years ago, Braniff has pioneered many achievements in air travel and has grown step by step with the continuing advances in commercial aviation.

Braniff's current investment program in new aircraft reflects the confidence this great carrier has in the further and rapid growth of air traffic.

We are happy that this great new General Motors Turbo-Prop power development has received such enthusiastic acceptance by airlines. We congratulate Braniff International Airways on this important step in the never-ending progress of air travel.

***Braniff airliners powered by Allison Turbo-Prop will give you . . .***

**FASTER FLIGHTS** than any commercial airliner now flying—cruising speeds of over 400 miles an hour

**SMOOTHER TAKE-OFFS** — and from airports now served only by smaller aircraft

**HIGHER CRUISING ALTITUDE** for greater latitude in selecting favorable flying conditions

**NEW COMFORT AND CONVENIENCE** —unprecedented new standards of smoothness and quiet in air travel

**HIGHEST DEPENDABILITY**—proved by Allison's record of more than 8 million hours of jet engine flight time

*The Allison Turbo-Prop is a gas turbine engine, similar to a jet, but its tremendous power is geared to a matching Aeroproducts Propeller for higher efficiency and better fuel economy.*

**ALLISON**
**TURBO-PROP POWER**

ALLISON DIVISION OF GENERAL MOTORS, Indianapolis, Indiana

AMERICAN BUILT FOR THE JET ERA IN AIR TRAVEL

terceptor. . . . H. Chapman Rose, former Under Secretary of the Treasury, has been re-elected to the Board of Directors. He relinquished his seat in 1953 to take the Government post.

• **Walter Kidde & Company, Inc.** . . . The Aviation Division has issued a brochure on its new high-pressure Fiberglas containers for pneumatic systems. The lightweight, noncorrosive, shatterproof, spherical containers are designed to hold compressed air at 3,000 psi pressure. They are intended for use as stored-energy sources in aircraft, ground service equipment, and guided missiles.

• **Kollsman Instrument Corporation** has issued a brochure explaining the scope of its activities in the optical field. The company's optical products for aviation and military use include periscopic, handheld, and photoelectric sextants; periscopes used on antiaircraft skysweepers; telescopes used in radar bombing and navigation systems; astrocompasses; sky compasses; photoelectric trackers; and binoculars.

• **Lear, Incorporated,** has established two operating companies abroad in support of its expanded European operation. A Swiss subsidiary, Lear, S.A., has been established in Geneva, where offices, laboratories, and shops have been set up at Cointrin Aeroport. A German subsidiary, Lear Electronic, GmbH, has been formed at Reim, near Munich. Board Chairman William P. Lear, AFIAS, moved his residence to Geneva last September to expedite the company's European expansion program. . . . Lear's new MA-1 aircraft compass, developed for the Navy Bureau of Aeronautics, is in production at the Grand Rapids Division. It is a gyro-slaved directional system designed for use under all operating conditions. In normal operation, the directional gyro of the MA-1 is slaved to a flux valve to provide gyro-damped magnetic headings on the indicator. Wherever magnetic readings become unreliable, as at high latitudes, on aircraft carriers, or during magnetic storms, the MA-1 may also be operated purely as a gyro directional system unaffected by the earth's magnetic field. Under this mode of operation, a dial on the cockpit controller is set to the existing latitude, and a selector switch is thrown to unslave the gyro from the flux valve. Regardless of magnetic compass fluctuations, the Lear directional system will then indicate true course within specified close tolerances for extended periods while automatically compensating for errors produced by the rotation of the earth. Lear claims the following advanced features for the MA-1:

(1) High-accuracy directional gyro with a random-drift rate of less than 4° per hour.

(2) Tubeless amplifier using silicon transistors and magnetic amplifiers for a high degree of reliability and miniaturization.

(3) Printed circuits which make possible substantial production economies and permit simple replacement of entire circuits in the field for easier servicing.

(4) Multiple indicators which can provide course readings at up to three different remote locations in the aircraft. The system is compactly packaged and weighs only 16.7 lbs.

**The Northrop F-89D Scorpion carries 104 rockets in large wing-tip pods—52 in each pod. Beneath each wing is an extra fuel tank.**

• **The Liquidometer Corporation** . . . The first transistorized aircraft fuel gage to operate at 100°C. has been developed by this company. Using silicon transistors, it is less than half the size of present vacuum-tube models. It operates as an integral part of a capacitor-type measuring system. Liquidometer also has designed a kit around a version of the transistorized gage to meet the fuel-measurement needs of the growing number of jet aircraft that carry auxiliary tanks. If the auxiliary tanks are jettisoned with fuel still in them, a switch in the indicator moves the pointer back to zero. The elimination of vacuum tubes means longer life and reduced maintenance. No shock mounting is required, and no tubes have to be replaced. The new fuel gage operates at 115 volts, 400 cycles.

• **Lockheed Aircraft Corporation** . . . Work on a preliminary design study project for nuclear-powered aircraft, which Lockheed has been conducting several years for the Air Force, will be transferred to the Georgia Division this summer. The project has been carried on at Burbank as a joint effort of the California and Georgia Divisions. . . . The Georgia Division is handling electronic modification work on a large number of B-47 jet bombers for the Air Materiel Command.

• **Manning, Maxwell & Moore, Inc.,** has purchased a $250,000 transfer machine for mass production of valve bodies at its Watertown (Mass.) plant. Employing many of the principles of automation for the first time in the valve industry, the machine is used in manufacturing Hancock gate-type high-pressure steel valves. The transfer machine, which requires only one operator, replaces six other machines of various types. It produces about 73 finished valve bodies per hour as compared with 19 by the previous method. When the automatic machine is fully loaded, 30 platens, each carrying a rough forging of a valve body, pass through 26 stations for drilling and other simultaneous cutting operations.

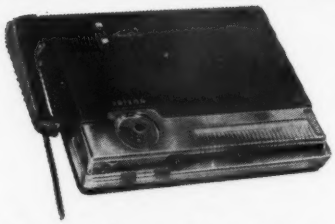
• **Marquardt Aircraft Company** is producing the power plant for the Bomarc IM-99 interceptor missile, which will be manufactured by Boeing Airplane Company in Wichita, Kan. The engine has been under development several years and has been ground-tested at the Marquardt Jet Laboratory in Van Nuys, Calif.

• **Minneapolis - Honeywell Regulator Company** . . . The expanding Transistor Division, formed 2 years ago in the company's main plant in Minneapolis, will be moved to the Boston area. Facilities will be leased there, according to a recent announcement, to house the Division's engineering, production, sales, and other departments. A new Applied Research Section will be established to expand the application of high-power transistors to new products. Basic research work in transistors will continue at the Honeywell Research Center in Minneapolis. . . . The Air Force Academy Construction Agency and Minneapolis-Honeywell Regulator Company are conducting experiments at the site of the Air Force Academy in Colorado Springs, Colo., to discover what "indoor climate" offers the most favorable study conditions for cadets. Two model dormitory rooms have been equipped with instruments that record air temperatures at six points and chart the effects of the sun, air movement, humidity, and other conditions that affect human comfort and efficiency. The rooms also have automatic temperature controls so that indoor conditions can be regulated and the effects of the changes recorded. These data will be compared with reports from several Air Force second lieutenants who are living in the laboratory rooms. The problem of student comfort is serious in the Colorado area because of intense daytime sunlight, cold nights, rapid outside temperature variations, and climatic changes.

• **Northrop Aircraft, Inc.,** will build a supersonic jet trainer for the Air Force in its main plant at Hawthorne, Calif. No details have been announced. . . . Northrop engineers have constructed a midget shake-test device many times smaller than existing devices and requiring no more current than a household electric iron. Called "Earthquake Ernie," it can apply a force of 55g's to guided-missile electronic components weighing more than 1,000 lbs. Ernie was designed to test the effects of vibrations ranging from 5 to 600 cycles per sec. on air-frame sections housing electronic equipment intended for use in the Snark SM-62 guided missile. Northrop engineers, realizing that unknown vibrations on take-off were causing excessive strain, particularly on electronic instrumentation inside the guided missile, invented Ernie to simulate conditions encountered on a missile launch so that vibration effects on full-system components could be recorded prior to actual flight. In the past, only small subassemblies or individual electronic "black boxes" could be shaken with existing vibration equipment. Moreover, it was found that the more powerful magnetic shakers affected sensitive instrumentation in the electronic components. The new shaker not only allows large sections to be tested but precludes adverse effects on electronic units by substituting hydraulic for magnetic force. The shaker operates

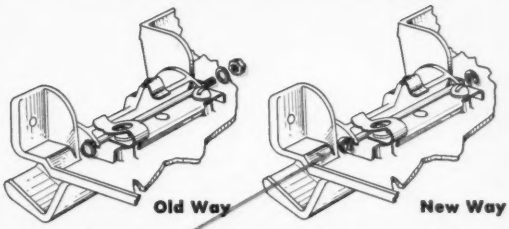
# 5 Waldes Truarc rings eliminate parts, speed assembly, in light, compact dictating machine

## Edison's "V. P." Voicewriter



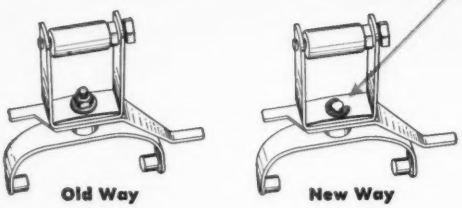
Edison engineers built this new dictating instrument for small size, light weight, and rugged performance. Waldes Truarc rings replace old fashioned fasteners, cut production costs; keep unit light, compact, and achieve faster more economical assembly.

## Disc Lever Cover Assembly




Two Waldes Truarc E-Rings (Series 5133) replace nut, bolt, washer assembly, eliminate one component and assure precise alignment of parts. Truarc rings facilitate pivoting without binding. Production assembly time is decreased.

## Lift Bracket and Fork Assembly




A single, easily assembled Waldes Truarc E-Ring (Series 5133) replaces nut-bolt-washer fastening. Free pivoting is assured, one component eliminated, labor and material costs reduced.

## Clutch Plate Assembly

Two Truarc E-Rings eliminate staking operation, prevent damage to spring coil. Simple assembly operation speeds production, eliminates rejects, reduces labor and material costs.

**Whatever you make,** there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

**36 functionally different types**... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

**More than 30** engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today. Let our Truarc engineers help you solve design, assembly and production problems, without obligation.

**For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!**

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Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
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AE-078

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from either a vertical or horizontal position and has a 1/4-in. stroke. The heart of the new test device is a specially built two-stage electrohydraulic servovalve which makes possible precise control of the hydraulic power. An amplifier-like exciter transmits electronic impulses to the valve's pilot spool, which controls the rapid movements of the piston rod to shake the specimen. Hydraulic pressure is built up to 3,000 psi before actual operation begins. A 75-hp. electric motor drives a hydraulic pump to operate this electrohydraulic vibration device. Among several engineers responsible for developing Ernie were Kent Proctor, MIAS, and Lee Beydler, TMIAS.

• **Pan American World Airways, Inc.,** has placed an order with the Electronics Division of Curtiss-Wright Corporation for electronic flight simulators to be used in training crews for its coming fleet for 48 jet transports. One simulator representing the Douglas DC-8 and another for the Boeing 707 will be delivered in 1958, 6 months in advance of the first airplanes. P.A.A. is about to take delivery of a Curtiss-Wright simulator for the Douglas DC-7C, long-range piston-engined transport. . . . P.A.A. has issued a booklet showing how the development of air-freight service has changed the concept of marketing. Cost comparisons between air and surface shipping are presented to prove that often it is cheaper to ship by air.

• **The Parker Appliance Company . . .** Two new products have been announced by the Rubber Products Division in Cleveland. A new synthetic rubber, developed for high-temperature fuel service by the Parker Rubber Research and Development Laboratory, has been found to be ideally suited for soft-seat sealing applications. The new Compound 36-551 is furnished in special molded shapes and bonded parts, fabricated to customers' specifications, as well as in standard O-ring seals. A new grease that extends the service life of synthetic rubber O-rings is Parker O-Lube, which is recommended especially for low-pressure pneumatic and vacuum systems. The grease is applied to both the O-ring and the metal surfaces over which the O-ring must slide. After the original assembly lubrication, additional application normally is not necessary in pneumatic systems.

• **Phillips Petroleum Company . . .** Some 20 representatives of the Air Force and of companies holding USAF research and development contracts attended a conference on jet aircraft hydrant fueling May 8 and 9 in Bartlesville, Okla. Phillips, which sponsored the conference, has an Air Force contract to make a design study of the most practical hydrant fueling systems.

• **Radioplane Company,** of Van Nuys, Calif., has completed its new plant in El Paso, Tex. The building has 25,000 sq.ft. of floor space. About 200 persons will be employed in El Paso to do modification, maintenance, and repair work on drone aircraft and to make parachutes to be used in recovering drone and missile aircraft. At the dedication of the building, company officials said they envisioned this plant as merely the initial step in a long-range program to develop a large aircraft manufacturing center at El Paso. Northrop Aircraft, Inc., Radioplane's parent company, has purchased a 591-acre site in the Newman Road industrial tract 10 miles north of El Paso.

• **J. B. Rea Company, Inc. . . .** In an effort to remove some of the mystery surrounding electronic computers, this company has prepared a series of recorded lectures and slides to explain the basic principles of their operation in terms that a layman can understand. These lectures assume a minimum mathematical and technical background, yet contain all the basic information needed to understand computers. They will be loaned to colleges for short periods without charge. Service clubs and fraternal organizations may rent the lectures and slides for a nominal fee. The lectures were prepared by W. V. Neisius, Director of Computer Applications, who was formerly Professor of Mathematics at Georgia Institute of Technology.

• **Ryan Aeronautical Company . . .** What is believed to be the first qualification test run of a jet engine and its control system in the vertical position was completed recently in Ryan's new $375,000 vertical test cell. This cell, which permits operation of the engine in both horizontal and vertical positions, was built primarily for testing propulsion systems intended for use in VTOL airplanes. The recent 25-hour test run included 15 hours in the vertical position. . . . Ryan has been selected to build afterburners for a new, extremely high-thrust jet engine developed by the Allison Division of General Motors Corporation. In announcing that it won the contract competition, Ryan did not identify the engine, which is still under security wraps.

• **R. Dixon Speas . . .** John J. Casey has resigned as Assistant Vice-President for Maintenance, American Airlines, Inc., to join the staff of R. Dixon Speas, Aviation Consultant, LaGuardia Airport, New York. A graduate of Massachusetts Institute of Technology, Mr. Casey served in the Air Force during World War II. He has been with American Airlines for the past 10 years, starting as Manager of Engineering in the Cargo Department.

• **Sperry Gyroscope Company Division of Sperry Rand Corporation . . .** Sperry has formed a new Microwave Electronics Division at its plant in Great Neck, N.Y. An announcement said the change reflects the company's increasing activity in large-scale programs for present and future surface and air-defense systems, guided-missile systems, and other vast radar and electronic systems for the Armed Forces. The new division will employ more than 800 persons, including 200 engineers, in development and production of weapon support systems, Microline test equipment, antennas, and precision components requiring specialized engineering and production techniques. The division also will reorganize and expand operations for additional instrumentation and standards for advanced research laboratories, special radar systems, and target simulators, computers, and evaluators for radar, electronic, and inertial guidance systems. Employees presently engaged in this work are being consolidated under the new division management. . . . A new West Coast engineering facility, to be known as

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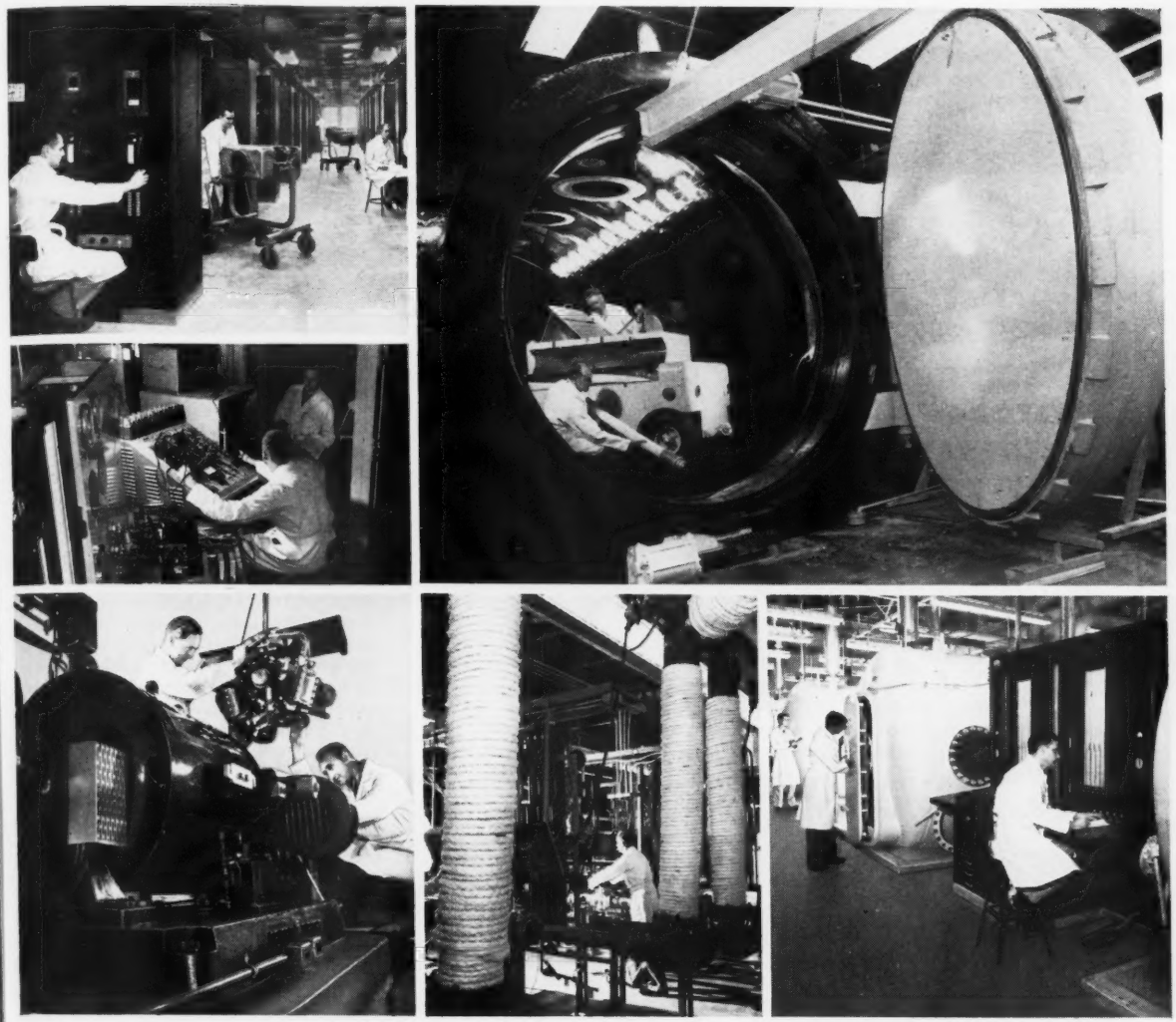

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| DAMPING | | | | |
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| SIZE 18 | 2.4 OZ. IN. | 5000 | 25/1 | .5% |
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the Sunnyvale Development Center, is being established this summer at Sunnyvale, Calif., by Sperry Gyroscope Company. Advanced research and development projects conducted by this Western group will be in the fields of radar, fire control, servomechanisms, and guided-missile systems. A small group of scientists will be transferred from Sperry's headquarters at Lake Success, N.Y., to form the nucleus of the Sunnyvale engineering staff. Convenient to four engineering schools, the Sunnyvale Development Center will occupy two buildings of 10,000 sq.ft. each. The Sunnyvale group will initiate development work on new weapons systems and carry these projects to completion of workable production designs based on thoroughly tested prototypes. Actual manufacture of equipment from these new designs will be performed at established Sperry manufacturing facilities.

• **Thiokol Chemical Corporation** . . . Douglas engineers working on the F4D Skyray have developed a new method of molding in place hermetic seals composed of Thiokol liquid polymer compounds. The seals are for electrical wiring passing through bulkheads, and they must withstand critical pressure and temperature differentials. Eliminating difficulties involved in using standard aluminum plug-in receptacles, the technique consists of passing wires through the opening in the bulkhead and then injecting the Thiokol compound into hemispherical plastic molds around the wires to form the seals. The base for the sealing compound is a solventless liquid that converts entirely to a rubber at room temperature without shrinkage. The cured rubber develops excellent adhesion to glass, metals, and plastics and will withstand temperature cycling of −65°F. to approximately 300°F. Hermetic sealing of wires through bulkheads by this method has resulted in considerable savings of time and cost. The seals can be applied at any time during plane assembly or in the field. The same method could be used for hermetic sealing of hydraulic lines or cable passing into or through pressurized areas, according to the company.

• **United Air Lines, Inc.** . . . An $800,000 electronic flight simulator representing the Douglas DC-8 jet transport will be built for United by Link Aviation, Inc. The simulator will be installed at United's Flight Training Center in Denver, in 1958, a year before the first of its 30 DC-8's will be delivered.

• **Vertol Aircraft Corporation** . . . The Air Research and Development Command has designed emergency, inflatable pontoons for Vertol's H-21 tandem helicopter. The pontoons will be manufactured by Vertol and installed in six of the "flying bananas" that are used to carry supplies to the Texas Tower radar outposts more than 100 miles off the Atlantic coast. The pontoons are made of rubberized nylon and are carried flat on each side of the helicopter. In an emergency, they can be inflated with compressed air in a few seconds. When inflated, they are 4 ft. wide and 7 ft. long.

• **Vickers Incorporated** has issued an illustrated bulletin describing in capsule form its complete line of air-borne oil-hy-

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draulic components and complete systems. Six new air-borne valves are included.

• **Westinghouse Electric Corporation . . .** The Sunnyvale (Calif.) plant will aid in designing and will build and install the nozzle, test section, and diffuser of a 21-in. hypersonic wind tunnel. Capable of velocities from Mach 4.5 to Mach 9.0, the hypersonic tunnel is expected to go into operation late in 1957 at the Jet Propulsion Laboratory of California Institute of Technology. Westinghouse said machine work must be held to infinitesimally close tolerances—as close as 0.0002 in. New methods of gaging must be devised and new cooling techniques provided.

• **Winder Aircraft Corporation . . .** Major Gen. Kenneth B. Bush, USA (Ret.), has been engaged for planning and administrative duties. General Bush joined the Army in 1917 and served in both World Wars. Most recently, he was Chief of Staff of the Northwest Service Command, Adjutant General of the Far East Command, and a member of General MacArthur's staff in Tokyo.

## IAS SECTIONS

### Hampton Roads Section

On April 28, some 120 members and guests of the Hampton Roads Section visited a Nike guided-missile installation as guests of "B" Battery, 56th AAA Missile Battalion. A conducted tour of the missile-launching area included demonstrations of the preparation, checking out, and fueling of the missiles; an inspection of the underground storage facilities; and a demonstration of the preparations for firing the missiles.

In the fire-control area, the officers and men of the battery, while simulating an alert, enacted their missile-firing procedures from the time of the alert until the missile warhead was exploded on the target aircraft.

A tour of the administrative and personnel facilities concluded a most interesting field trip.

LEWIS R. FISHER
*Recording Secretary*

*Space Flight*

### New York Section

J. Gordon Vaeth, Head of the New Weapons and Systems Division, U.S. Navy Special Devices Center, Office of Naval Research, was the afterdinner speaker at the April 26 meeting in Paramus, N.J. After an introduction by Theodore F. Hammen, Jr., who presided, Mr. Vaeth delivered a talk on "Training for Flight Beyond the Earth."

According to the speaker, space travel changed from the realm of science fiction into that of reality when on July 29, 1955, the White House announced the initiation of a satellite program for the International Geophysical Year.

The project is known under the code name VANGUARD and has The Glenn L. Martin Company and the General Electric Company as its main contractors. The plans call for the shooting of 12 missiles into outer space between the middle of 1957 and the end of 1958. The first satellites will be spheres 20 in. in diameter. They will constitute the last stage of three-stage rockets to be fired from Patrick AFB in Florida. It is hoped that many of the missiles will reach altitudes varying between 200 and 400 miles and will settle down on orbits circling the earth for days, weeks, or even more than a year.

If this project meets with success, the speaker said, more ambitious plans undoubtedly will be realized later. A visit to the moon and photographing of its surface probably will come next. This should be followed by trips to the other planets.

Personnel of manned space ships will have to be trained very thoroughly. Not only will they have to be able to survive the trip and the landings, but they will be called upon to take many scientific measurements and to do repair work on the vehicle and the scientific instruments when necessary. An intensive training program will have to be initiated for the personnel.

The lecture was followed by an extensive discussion in which flying saucers, the possibility of shipping colonies of men and women to stars that would be reached only after several generations, and the advantages to be drawn from a reduction in time in consequence of Einsteinian relativity figured prominently.

NICHOLAS J. HOFF
*Secretary-Treasurer*

### Rocky Mountain Section

The fourth meeting of the Rocky Mountain Section was held on April 20 at the University of Colorado, with representatives of the IAS Student Branch acting as hosts. The Boulder Division of Beech Aircraft Corporation was host at a social hour preceding the dinner meeting.

Following the dinner, Dean C. L. Eckel of the College of Engineering introduced a number of officials and their wives from The Glenn L. Martin Company, the Air Force Academy, Beech Aircraft, United Air Lines, and the University of Colorado.

The speaker of the evening, Major Gen. Franklin O. Carroll (Ret.), was introduced by Paul Lord, Chairman of the University Student Branch.

General Carroll traced the development of the Air Force research and development program from shortly after World War I to the present, mentioning the establishment of Wright Air Development Command, Holloman AFB, and Edwards AFB as outstanding examples of the growth of the Air Force research establishment.

In the latter part of his address, General Carroll devoted particular attention to the origin and construction of the Arnold Engineering Development Center at Tullahoma, Tenn., where he was the Commanding General during its formative years, 1949–1952. Illustrating his talk with numerous pictures of construction work in progress at Arnold, General Carroll pointed out that the Tullahoma base will have the largest and most complete transonic, supersonic, and hypersonic testing facilities in the Air Force establishment. Of special interest were the illustrations of a tube 750 ft. in length by 4 ft. in diameter which can be used interchangeably as a vacuum reservoir to augment one of the blowdown tunnels or as a giant shock tube capable of developing hypersonic Mach Numbers and temperatures on a large scale.

After the meeting, members and guests were shown the Engineers' Days Exhibits set up in the various departments of the College of Engineering at the University.

ARTHUR W. GILMORE, *Secretary*

*Air Defense*

### St. Louis Section

Air defense, a relatively new military science for the United States, was discussed at the confidential meeting of March 23 by Lt. Col. C. J. Butcher, Director of Plans and Requirements, Hq. Air Defense Command, Colorado Springs, Colo.

Pointing out that the need for an integrated system of air defense for the continental United States did not become apparent until 1946, he noted that within the next 2 years Congress appropriated money for 78 radar warning stations. The Air Defense Command was formed in 1951 and later was merged into the Continental Air Defense Command.

Colonel Butcher defined the major threats of air invasion as (1) coming

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from over the North Pole, (2) circumventing Alaska to attack the West Coast, or (3) by-passing Iceland to hit the East Coast. The four air-defense functions are detection, identification, interception, and destruction.

The detection phase is handled by land-based radar coverage stations, seaward extensions of radar using long-range aircraft and Texas Towers, and Ground Observer Corps civilian defense units in the United States and Canada. The Air Defense Identification Zone activity involves a correlation of all flight plans within and coming into the United States. Flights conducted above 4,000 ft. average 30,000 daily within this country and 600 from overseas.

Colonel Butcher's comments on interception and destruction were in the form of a review of existing operational aircraft, presently contemplated operational aircraft, antiaircraft guns, and ground-to-air missiles.

The speaker also discussed the threat of the intercontinental ballistic missile.

Because of the newness of air defense, he said, a need exists to educate industry and to indoctrinate the Air Force regarding future fire control systems, with emphasis on the elements of time, flexibility, and reliability.

▶ Roger C. Sonnemann, Personnel Manager of McDonnell Aircraft Corporation, spoke on "The Aeronautical Engineer at the Professional Level" at the February 22 meeting. He reviewed the status of an engineer in legal, financial, industrial, and professional terms.

FREDERICK H. ROEVER
*Recording Secretary*

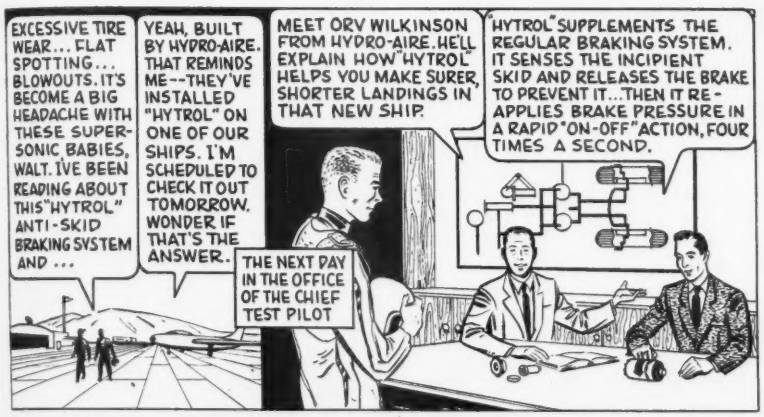
### *Meetings*

## San Diego Section

A joint meeting was held on April 24 with the members of the IAS Student Branch on the campus of San Diego State College. Robert J. Woods, Airplane Design Consultant, Bell Aircraft Corporation, presented a paper on "Suggested Supersonic Design Considerations."

Mr. Woods brought out several thought-provoking ideas on the design of supersonic aircraft. The main theme centered around the exchange of aircraft-structure and equipment weight for power-plant-installation weight as design speeds are increased and emphasized the relative importance of the power-plant system in obtaining optimum supersonic performance. Mr. Woods concluded his paper with the view that engine and airplane design must go "hand in hand" and that the power plant must be specifically designed for the mission requirements, just as the airplane is.

ANOTHER BLOWOUT. THAT BLASTED LOCKED WHEEL PROBLEM!
THAT'S THE THIRD ONE THIS WEEK, JIM.
HOW DO YOU ACCOUNT FOR IT, WALT ?
SAME AS THE OTHERS. WHEN YOU COME IN FAST, YOU HAVE NO "FEEL" FOR THE BRAKING ACTION. TOO MUCH BRAKE PRESSURE LOCKS THE WHEEL AND IT BLOWS BEFORE YOU KNOW WHAT'S HAPPENING. THOSE SKIDS OCCUR TOO FAST FOR HUMAN REFLEXES.


EXCESSIVE TIRE WEAR... FLAT SPOTTING... BLOWOUTS. IT'S BECOME A BIG HEADACHE WITH THESE SUPERSONIC BABIES, WALT. I'VE BEEN READING ABOUT THIS "HYTROL" ANTI-SKID BRAKING SYSTEM AND ...
YEAH, BUILT BY HYDRO-AIRE. THAT REMINDS ME--THEY'VE INSTALLED "HYTROL" ON ONE OF OUR SHIPS. I'M SCHEDULED TO CHECK IT OUT TOMORROW. WONDER IF THAT'S THE ANSWER.
THE NEXT DAY IN THE OFFICE OF THE CHIEF TEST PILOT
MEET ORV WILKINSON FROM HYDRO-AIRE. HE'LL EXPLAIN HOW "HYTROL" HELPS YOU MAKE SURER, SHORTER LANDINGS IN THAT NEW SHIP.
"HYTROL" SUPPLEMENTS THE REGULAR BRAKING SYSTEM. IT SENSES THE INCIPIENT SKID AND RELEASES THE BRAKE TO PREVENT IT...THEN IT RE-APPLIES BRAKE PRESSURE IN A RAPID "ON-OFF" ACTION, FOUR TIMES A SECOND.

THE BASIC UNIT OF "HYTROL" IS A SKID DETECTOR MOUNTED IN EACH WHEEL. EACH SENSES THE SKID AND TRANSMITS AN ELECTRICALLY CONTROLLED SIGNAL TO A SOLENOID VALVE IN THE BRAKE PRESSURE LINE. FAIL-SAFE ACTION ASSURES BRAKES UNDER ANY CONDITION.
WALT'S BRINGING HER IN NOW, MR. WILKINSON. GOOD LANDING!
YES, IN TESTS "HYTROL" HAS DECREASED THE LANDING ROLL BY AS MUCH AS 30%. THE PILOT MAY LAND WITH BRAKES FULLY APPLIED AND KEEP FULL PEDAL FORCE.
"HYTROL" PREVENTS BRAKE ENGAGEMENT PRIOR TO TOUCHDOWN AND THE WHEELS WON'T LOCK IF THE PLANE "PORPOISES."

I'M SOLD ON "HYTROL", JIM. THAT WAS AS NICE A LANDING AS I'VE EVER EXPERIENCED.
NOT A MARK ON THE TIRES, EITHER. AND NO OVERHEATING OF THE BRAKES. YEP, HYTROL'S THE ANSWER TO LANDING A SUPERSONIC FIGHTER.

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***hytrol Eliminates Blow-Outs*** due to skidding; and a blow-out can cost much more than just a tire!

***hytrol Increases Aircraft Utilization:*** Hytrol users report a marked reduction of unscheduled repairs.

***hytrol Minimizes Runway Mishaps*** due to overshooting, swinging or late take-off rejections — and safety pays off in dollars!

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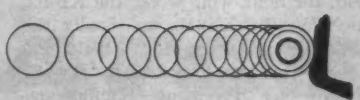

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**Mrs. Alberta Alksne, MIAS, and Norman R. Bergrun, AFIAS, both of the scientific staff of NACA's Ames Aeronautical Laboratory, point to the display prepared by the San Francisco Section for the Science-Aviation Fair. About 5,000 school children and teachers attended the event at San Francsico's International Airport.**

C. L. Bates, Assistant Chief Engineer, Ryan Aeronautical Company, as technical chairman of the meeting, introduced the speaker and served as moderator during the question period following the paper. It was felt that this joint meeting was beneficial to both organizations, and it is hoped this will be one of many such meetings the San Diego Section will have with the Student Branch of State College.

▸ "Development of High-Performance Fighters" was the subject of a presentation by Ralph L. Bayless, Chief Engineer, and E. D. Shannon, Engineering Staff Specialist and formerly Chief of Flight Test, Convair, A Division of General Dynamics Corporation, San Diego, at the April 3 confidential meeting. The paper was divided between discussions of the engineering development of fighter airplanes and some of the more interesting flight-test results presented by Mr. Bayless and Mr. Shannon, respectively. Early jet aircraft studies at Vultee Field, the delta-wing work, the XF-92, the XFY, the XF2Y, and finally the F-102 were all discussed to make the meeting of great interest. R. C. Sebold, Vice President—Engineering, Convair, served as technical chairman of the meeting and introduced the speakers.

### *Committee Activities*

One of the most important and interesting committee activities presently occurring within the San Diego Section is that of planning the 1956 Turbine-Powered Air Transportation Meeting. This will be the first national IAS meeting presented in the San Diego area, and both the committee and the membership at large have looked on this opportunity with a great deal of enthusiasm.

The committee was formed November 1 for the express purpose of organizing, promoting, and conducting the 1956 National Turbine-Powered Air Transportation Meeting of the IAS. It was decided to staff the committee principally with personnel not already engaged in Section activities in order to have as much representation as possible from the San Diego Section membership. It was felt that this approach would give more members an opportunity to participate in IAS work.

Earl R. Hinz is General Chairman of this committee, and Charles L. Blake is Cochairman.

The Chairmen and Vice-Chairmen, respectively, who are responsible for the various phases of the meeting are: *Program*, William C. Keller and Harvey C. Tafe; *Hospitality*, Philip M. Klauber and Jack Porterfield; *Publicity*, John D. Donaldson and Cy Greeves; and *Financial*, Frank E. McCreery and Robert S. Winter. The committee's Secretary is James Kerns. F. D. Applegate is in charge of *Displays*.

The IAS Student Branch at San Diego State College is represented on the committee by its Chairman, Chase Allen.

R. A. FUHRMAN
*Corresponding Secretary*

## San Francisco Section

This Section cooperated with the Elementary School Science Association and the California Aviation Education Association in sponsoring a Science-Aviation Fair at the San Francisco International Airport on April 14.

The purpose of this activity was to arouse interest at the elementary and high school levels so that more students will want to make a career in the aviation field. An estimated 5,000 persons, including 1,500 teachers, came to the Fair.

Mrs. Alberta Alksne, MIAS, and Norman R. Bergrun, AFIAS, both Aeronautical Research Scientists at Ames Aeronautical Laboratory, NACA, were members of the Fair committee. E. W. Robischon, Western Region Manager of the IAS, helped the Section obtain models and photographs for the display.

J. A. BERT, *Secretary*

## Seattle Section

Bill Taylor presided at the April 18 meeting held at the Seattle Tennis Club. Colonel W. T. Ensley, Air Force Plant Representative at Boeing, introduced the guest speaker, Col. R. E. Evans. For the past year Colonel Evans has held the position of Deputy Chief, Tactical Requirements Division, at SAC Headquarters. He spoke on "The Mission and Purpose of the Strategic Air Command."

Colonel Evans emphasized that the main objective of SAC is to see that the United States does not go to war. Besides this, the SAC mission is to conduct the Strategic Air Offensive, utilizing available weapons. SAC Headquarters are located in Omaha. SAC is comprised of the 2nd, 8th, and 15th Air Forces. One of the biggest problems that the Air Force has is the loss of trained personnel to industry; for 4 years of training there is only 1 year's return.

Colonel Evans said the B-47's have compressed the size of the world. In-flight refueling has increased the range of the medium bomber to make it an intercontinental bomber. He feels that it will be a long time before missiles take the place of manned bombers.

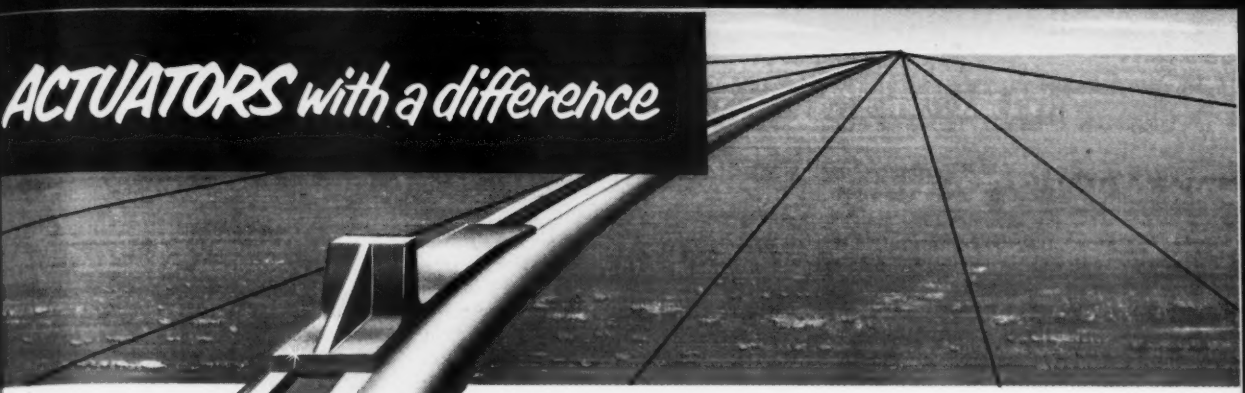
In the event of another war, the aggressor would have a definite advantage. Colonel Evans discussed what plans of attack would be pursued if we were engaged in another war. He concluded by showing the crest of SAC, pointing out that the mailed fist with lightning bolt and olive branch denotes strength and force but an ultimate goal of peace.

ELAINE GETHING, *Secretary*

## Tulsa Section

Forty-two members and guests attended the April 3 meeting to hear a talk by J. L. Edman, Chief Technical Engineer, Airframe Components, Bendix Aviation Corporation. He spoke on the "Dynamics of Landing Gear Systems" developed through Bendix and Wright Field research. He illustrated his talk with slides and movies.

# ACTUATORS with a difference



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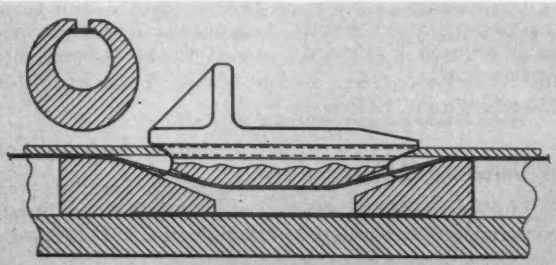


Schematic of longitudinal section indicates how free piston guides sealing ribbon against tube slot.

Views were shown of Bendix research facilities and test methods, and the problem of nosewheel shimmy was explained. Movies were shown of model tests on braking and shimmy. In conclusion, Mr. Edman showed the series of curves that Bendix has plotted to aid in the design of landing gear systems.

Chairman Clark L. Marks announced the formation of an Advisory Management Committee for the Tulsa Section. This committee consists of C. R. Strang of Douglas Aircraft Company, Inc., W. C. Lawrence of American Airlines, Inc., and Prof. J. C. Klotz of Tulsa University.

▶ Charles M. Seibel, MIAS, Chief Engineer of the Helicopter Division of Cessna Aircraft Company, spoke at the dinner meeting on January 10. There were 58 members and guests present.

Mr. Seibel spoke on Cessna research and development in the rotary-wing field. He started by selecting the specifications which were to be designed into the helicopter, proceeded with the mechanics of design and development through the use of a stationary test stand and a flying test bed to the final aircraft, and finally described the CAA testing and certification of the finished product. Then Mr. Seibel narrated a film taken during the development of the Cessna CH-1 helicopter.

RICHARD M. GILMORE, *Secretary*

## STUDENT BRANCHES

### California State Polytechnic College

Wanting to "do something" about the shortage of engineers, members of this Student Branch decided to talk to high school students throughout the state. The suggestion came from E. W. Robischon, Western Manager of the IAS.

Seven members were selected to visit the high schools from which they had graduated and make short talks urging the students to take courses that would qualify them to enter an engineering college. Each speaker was on familiar ground. It was thought that talking to the boys as a "fellow student" might prove more effective than the usual vocational approach by an older person.

The high schools varied in size and location, but the response was gratifying in every case.

Typical subjects covered in the talks were, "Why we are making these talks," "How to prepare for college," and "What an engineer does." The talks ran from 20 to 40 min., with a question period filling the remainder of the classroom session. Indicative of the interest shown was a request by one teacher that the talk be presented to two of his classes in addition to the one originally scheduled.

We believe this would be a worthwhile endeavor to carry on every year and that possibly it should be extended to the grade school level.

WARREN WILSON, *Chairman*

### The Catholic University of America

Donald E. Marlowe, Dean of the School of Engineering and Architecture, was the speaker at the February 23 meeting. His subject was "Problems Related to, and the Development of, Guided Missiles."

Drawing upon his experience as Assistant Director of the Naval Ordnance Laboratory, he discussed current types of missiles and guidance systems, bombs, and aircraft armament. In describing fighter-bomber combat, he touched on such matters as the best ranges to commence firing and the established ranges which minimize chances of self-destruction.

Chairman Nicholas R. Gallipoli and James R. McGrath were appointed to represent the Aeronautical Engineering Department on the Inter-Engineering Council.

JAMES R. MCGRATH, *Secretary*

### Georgia Institute of Technology

The following new officers have been elected: Fred R. DeJarnette, Chairman; William K. Andrews, Jr., Vice-Chairman; Eugene C. Knox, Secretary; and E. N. Pasyanos, Treasurer.

Roland Fuentes presided at the April 16 meeting, which was occupied mostly with a discussion of the forthcoming Southeastern Student Conference. Members were told they could be excused from their classes in aeronautics to attend the technical sessions (student paper competition).

EUGENE C. KNOX, *Secretary*

### Indiana Technical College

Norman L. Baker has been given the Outstanding Student Award for the spring term, and Bernard Hyle won the Outstanding Student Award for the year.

At the May 8 meeting, Mr. Krava spoke on VTO aircraft and a movie was shown entitled *Crescent-Wing Aircraft*.

Mr. Kemp, of the faculty, gave a talk on "The Helicopter" at the April 24 meeting. He was formerly with Sikorsky Aircraft Division of United Aircraft Corporation.

Motion pictures on *The VF-100* and *Test Flights of Experimental and Fighter Aircraft* were shown at the April 10 meeting.

WAYNE C. BOHANNON, *Secretary*

### Iowa State College

The April 25 meeting was a joint session of the Aeronautical, General, and Mechanical Engineering societies. The speaker was Alexander Lippisch, MIAS, Director of the Aeronautical Research Laboratory at Collins Radio Company, Cedar Rapids, Iowa. He was introduced by Jack Sevinsky, President of the student chapter of ASME.

Dr. Lippisch, as a German engineer, was famous for glider development and for designing the Messerschmitt 163, the first operational jet-propelled fighter. He came to this country in 1946.

His talk centered about the aerodyne, a wingless aircraft which he has designed at Cedar Rapids. Dr. Lippisch said that wings on modern aircraft are unnecessary—that the power source can function as a means of lift and stabilization. This is accomplished in the aerodyne by means of a combination of propeller and shroud. Force is produced by change of direction of airflow within the shroud. Much higher hovering efficiency is achieved than by present-day helicopters.

Several models of different scales have been test flown, with the biggest problem that of stabilization and control. A full-scale model is now under construction. A short movie showed the various models being test flown.

▶ The April 11 meeting was called to order by Vice-Chairman Carl Vollersen, who introduced the two speakers.

Jerry Beamish and Chuck Wooldridge, seniors in the Aeronautical Engineering course, told of the work and problems involved in attempting to increase speed and decrease turbulence in the Iowa State College wind tunnel. The job, which was commendably successful, involved use of a pressure rake, change of honeycomb and backing screen, and hours of hard work. For their efforts the two received credit in a "special problems" course.

MARVIN BAXENDALE, *Secretary*

### North Carolina State College

The following officers have been elected for next year: David Pierce, Chairman; Bill Frye, Vice-Chairman; Jesse Harrell, Corresponding Secretary; James Wallace, Recording Secretary; and Robert Bennett, Treasurer.

With the Engineer's Fair close at hand, final plans were made at the April 10 meeting and members were assigned to posts. The theme in the Aeronautical Engineering Department will be "The Birth of an Airplane." Visitors will be shown the story from beginning to end, with the wind tunnels and the structures lab playing the dominant roles. John Dawson is the IAS Fair Chairman.

KEITH E. VERBLE, *Secretary*

***Plant Tours***

### Northrop Aeronautical Institute

Thirty student members enjoyed a 2-day field trip to San Diego, Calif., April 13 and 14, which featured tours of Ryan Aeronautical Company, Solar Aircraft Company, and Convair facilities there.

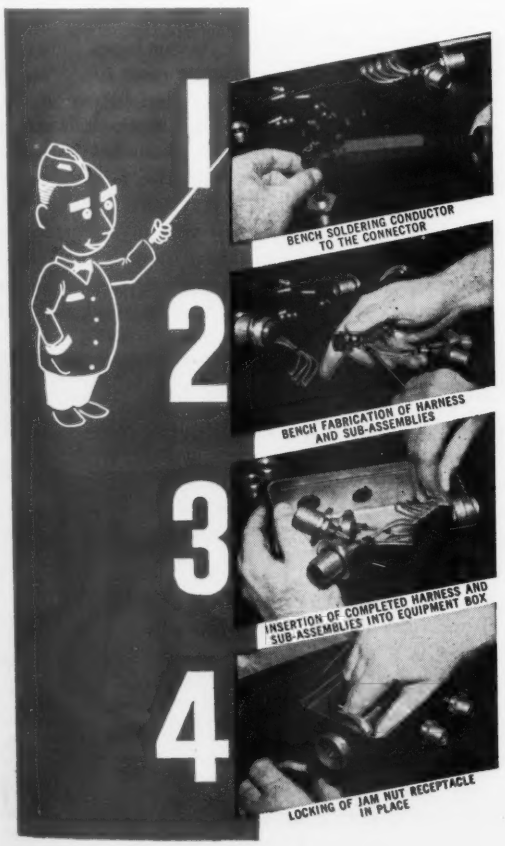
The first tour on Friday the 13th began at Ryan, where C. B. Burkholder of the Design Section conducted the tour. In the conference room, official welcome was extended by Frank Fink, Vice-President and Chief Engineer. Herman L. Braasch, Chief of the Aircraft Section, then discussed Ryan's development work in the vertical take-off field. He indicated that the VTO aircraft offers superior performance, mobility, and dispersal opportunities over conventional airplanes. Elimination of the usual heavy landing gear and flap installations allows the use of a heavier and more powerful engine. The resulting increase in power-to-weight ratio improves acceleration and overall performance, according to Mr. Braasch.

Robert A. Fuhrman, Chief of the Technical Section, outlined the functions of his section with emphasis upon the use of analog and digital computers. Ryan engineers who use the computers in solving their problems stay with the computer while it works so that they can see by early results whether to continue the work or to go back and think of something else. Computer specialists assist the engineers but are not left to run an unlikely program to complete solution. Mr. Fuhrman then showed performance curves and data on the Firebee drone missile in chart form, followed by a motion picture entitled *The Ryan Firebee* which showed assembly, launching, flight, and parachute recovery of the little swept-wing missile.

The plant tour included the Firebee production line, the engineering department, and the computers. W. W. Wood, Group Engineer—Computing, explained the functions of the various components of the IBM digital installation and the use of a Firebee with the analog computer in flight simulation work.

Lunch at the IAS Building was provided for the group by Ryan. Mr. Braasch, who is Corresponding Secretary of the San Diego Section, told about IAS activities in the area and the history of the IAS Building.

Tipton L. Wood, Training Coordinator at Solar Aircraft, took the group to Solar after lunch, where he introduced P. M. Klauber, Chief Administrative Engineer. Mr. Klauber outlined the history of Solar and its products before conducting a tour of production facilities for gas-turbine engines. Both the Mars and Jupiter engines were demonstrated in several applications: the Navy's T-45M-2 Portable Fire Pump, an Auxiliary Power Unit for the Douglas C-124C, and a pod-mounted APU, all powered by the Mars engine; and a Jupiter-powered air compressor for starting aircraft jet engines. The Mars is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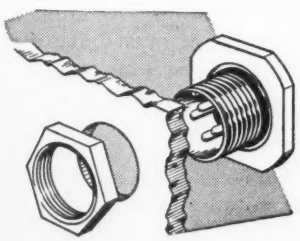

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# The Role of Modern Test Facilities in the Design of Aircraft Gear Drives

by John Morris

*Manager of Engineering, Western Gear Corporation*

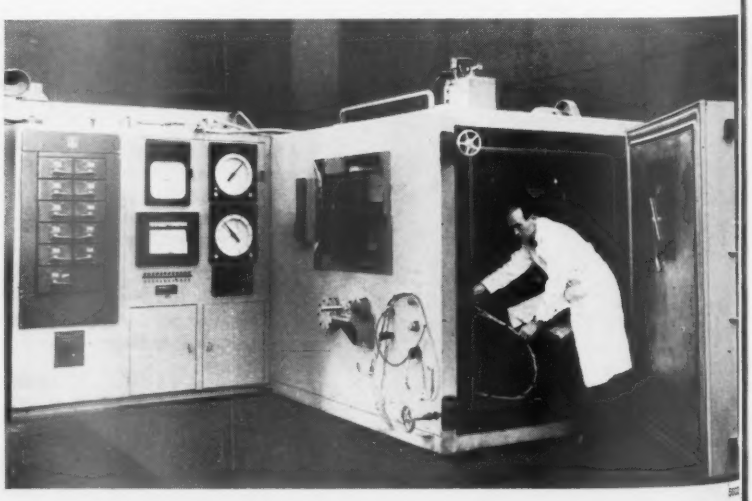
Modern aircraft, whether it be piloted or electronically guided, requires mechanical devices of utmost reliability. No longer can the designer depend entirely upon experience but must have available extensive equipment capable of producing the environments and loading conditions which will check the newly designed parts to the conditions encountered on its assigned mission.

This environmental test equipment must be operated by experienced personnel under the guidance of engineers capable of correlating and analyzing test results and their actual relation to final installations before a suitable product can be designed, produced, and proven. Mother Nature in her unlimited weather laboratory produces extreme variations of the elements in almost incalculable combinations. The laboratory must endeavor to precisely duplicate conditions. Altitude chambers at Western Gear Corporation (as shown in the photo at lower right) can carry the test part to the extremes of altitude beyond the reaches of piloted flight up to and in excess of 90,000 ft. Temperatures must be duplicated far below those normally encountered by present day military craft. Tests have been run at Western Gear as low as –300° F.

The salt spray of the sea and the steaming humidity of the jungle as well as the wind and dust of the desert are being duplicated daily in our block-long test laboratory. The tremendous speeds as well as the necessity for the utmost in contr produce forces in any directio which are simulated in Western Ge centrifuges in excess of 100 times th normal weight of the part. Studie of the reaction to shock loadings ar duplicated in our laboratory by im pact tests often running in excess o 200 G's.

The effects of wind, sand, dust rain, sunshine, snow, heat, cold vibration, impact, chemicals, lubri cants and materials must be evalu ated while constantly striving t increase load carrying ability, serv iceability and reliability of products Extensive testing is required t assure that no possible condition has been overlooked which ma cause a malfunction. An example o a test stand setup to check the oper ational characteristics for testing linear actuators is shown at upper left. The interrelation of magnet ism, electricity, gravity, vibrations forces, materials and chemicals under environmental conditions often poses the necessity of multi tudes of carefully controlled, pre cisely measured tests.

Western Gear engineering recog nizes these very necessary elements Therefore, in our block-long testing laboratory the most modern equip ment is provided to prove design concepts. Thus meticulous attention to perfection has made Western Gear the leader in the field of aircraft gearing and systems design. Why not let us assist you in your next power transmission problem? Western Gear Corporation, General Offices, P.O. Box 182, Lynwood, California.



hand-cranked to sustaining speed in the fire pump installation, and it started readily in each demonstration. The tour was followed by the showing of a film, *Solar Engineering Development*, and a question-and-answer period conducted by Mr. Klauber. Students examined a cutaway model of the fire pump, watched a demonstration of water-cooled turbine blades as developed at Solar, and enjoyed operating a working display board depicting the Solar Microjet control system for aircraft jet engines with afterburners.

Saturday's events began with lunch at the IAS Building provided by Convair. Carl Welti of Public Relations welcomed the group, and John Struthers, Wind Tunnel Manager, gave a preview of the tour. The tour began at the wind-tunnel building and included the assembly lines and flight line.

The first stop in the wind-tunnel building was the ERA 1103 computer room. Here Lee Dominick of ERA explained what the big machine can do and how it does it, while checks were being run to show the operation of the computer. Questions were encouraged, and all were answered in plain language by Mr. Dominick. The next stop was the control room of the tunnel, where Jack Quigley operated the tunnel while Mr. Struthers pointed out significant manometer readings. The working section contained a small sphere with pressure tap holes in its surface. When the blower was shut down, the group entered the tunnel itself and looked at the test sphere and the turning vanes at the corners of the tunnel. Will Carter, Group Engineer—Model Design, explained the construction of a wind-tunnel model of the F-102 and allowed the students to examine it closely.

The tour of the production line provided opportunities to go aboard several nearly completed 440 Metropolitan air liners to see the interior details of wiring, plumbing, controls, and furnishings. On the flight line tour, the group went aboard an Air Force model of the 440 which had an attractive blue interior. A feature of this transport is its integral passenger-loading stairway, which retracts into the fuselage in flight. The operation of the stairway was demonstrated at the conclusion of the tour.

GARLAND O. GOODWIN
*Vice-Chairman*

## Parks College of Aeronautical Technology

Jacques W. Harvey, of the Helicopter Division of McDonnell Aircraft Corporation, spoke on "Fatigue Design of Rotary-Wing Aircraft" at the May 3 meeting.

Mr. Harvey, who is working on the XV-1 convertiplane, started his talk by discussing preliminary design and aerodynamic studies in the wind tunnel.

The helicopter, of course, is a compromise. Fatigue design, he remarked, could be considered more an art than a science—when determining the loading, the engineer makes his calculations by theory, experience, and intuition.

After the helicopter is built, it is instrumented in order to measure expected loads and loads that may not have been anticipated. A motion picture showed the actual loads encountered by the rotor blade of the XHJD-1 helicopter.

Since it is too expensive to test 10 or 20 specimens, Mr. Harvey said, two or four are tested and a normal distribution curve is used to predict failure.

After the talk, a film on the McDonnell XV-1 convertiplane was shown.

GERALD PANEK, *Secretary*

## The Pennsylvania State University

Fifty engineering students attended the April 18 meeting.

James Tedeschi introduced the speaker, Mr. Cooley from United Aircraft Corporation. Mr. Cooley's talk was intended for seniors interested in preliminary design. The talk included performance problems, methods of solving these problems, and typical short cuts used by industry. What Mr. Cooley explained best was the overall picture of how industry attacks these performance problems.

▶ Fifty students also attended a special meeting on April 16 to hear a talk by William Schlegel, of Douglas Aircraft Company, Inc.

Mr. Schlegel described the organization of the Aerodynamics Section, its management, and the type of work done by each group. He also showed films on the Skyray, the B-66, and the Nike missile.

The meeting closed with presentation of third prize to Frank Bastidas and John Gusek for their entry in the IAS Student Paper Competition at the University of Maryland. Mr. Gusek described the experiment on which their paper was based.

JOEL PETERSON, *Secretary*

## Rensselaer Polytechnic Institute

The April 17 meeting was a joint session with the Eastern New York State Branch of the American Rocket Society. A. Hertzberg, Head of the Gas Dynamics Branch of Cornell Aeronautical Laboratory, Inc., was the guest speaker.

Mr. Hertzberg confined his remarks to the tools of hypersonic research: the hot-pebble hypersonic tunnel, the fast piston, and the shock tube. Of these, the shock tube alone can give shocks of the order of Mach 20. Rapid dissociation above Mach 10 makes analysis difficult. However, these chemical changes may be utilized. In fact, Cornell Aeronautical Laboratory is presently operating a shock tube for the sole purpose of obtaining dissociation.

PETER D. TANNEN
*Assistant Secretary*

## San Diego State College

The Student Branch held a joint meeting with the San Diego Section of IAS on the evening of April 24. More than 100 students and senior members heard Charles Morgan, Faculty Adviser, outline the brief history of the Student Branch. The meeting in the Campus Laboratory Auditorium marked the first anniversary of this Student Branch, which was formed under sponsorship of the San Diego Section.

The speaker of the evening was Robert J. Woods, an airplane design consultant of Bell Aircraft Corporation who participated in designing the Bell X-1, X-1A, and X-4 research airplanes. He is a graduate of the University of Michigan. His subject was "Supersonic Design Considerations."

Mr. Woods' main point was that today's supersonic airplanes have a limited flight duration because of the extremely high rate of fuel consumption by their powerful (but uneconomical) jet engines. He showed slides representing the specific fuel consumption of several types of engine. Then he explained the importance of the shape and position of the air inlets and exits.

▶ Thirteen members of the Student Branch toured the Miramar Naval Air Station on the afternoon of March 19.

A Navy pilot showed how the G-suit is worn and discussed performance of the Navy's jet fighters. Numerous jets were looked over on the apron, including a Grumman Cougar whose cockpit and cameras were displayed for close inspection. A color film explained aerial photo reconnaissance.

Convair's 20-min. film, *The Producibility Barrier*, was shown at the March 13 meeting.

MICHAEL D. CHILCOTE, *Secretary*

## Stevens Institute of Technology

Several student members made a tour of New York International (Idlewild) Airport on April 11. First the Port of New York Authority Building was visited where there was shown a large model of the airport as it will look when completed. Then Idlewild was toured, where students watched operations from the control tower

and were given a ride around the airport. The control tower and radar approach facilities were described.

EDWARD GRIFFITH, *Chairman*

### Syracuse University

Three new members were taken into the Student Branch at the April 18 meeting.

Joseph G. Cady, Faculty Adviser, announced he is leaving the school in June.

Three films were shown: *The Supersonic Wind Tunnel, Aerodynamic Forces on an Airfoil,* and *Compressibility Effects at Varying Angles of Attack.*

JAMES C. GYSEL, *Chairman*

### Tri-State College

Thirty-six members arrived at the NACA Lewis Flight Propulsion Laboratory in Cleveland on April 26 for a tour of the wind tunnels, test cells, and laboratories. The following day they visited the North American Aviation, Inc., plant in Columbus, Ohio. In the morning, they toured the assembly and shop areas. In the afternoon, the chief engineers of four different departments gave lectures on their respective departments. Thus the students were given some insight into the thought, procedures, and work involved in constructing an airplane. The 2-day field trip, they decided, was "well worth the classes missed."

Two movies were shown at the April 19 meeting: *Jet Test* and *Guided Missiles—Introduction and Theory of Operation.* The IAS banquet has been scheduled for May 24.

R. JULES DUSSIA
*Vice-Chairman*

### U.S. Naval Postgraduate School

Peter P. Wegener, AFIAS, of the Jet Propulsion Laboratory at California Institute of Technology, discussed "Problems and Methods of Studying Experimental Hypersonic Flows" at the April 18 meeting.

He indicated that little is known about the viscous effects in hypersonic flows. Approximations may be made in the laminar boundary layer, but much progress is needed to predict turbulent effects.

With slides, Dr. Wegener showed in particular where the perfect gas laws fail in the analysis of hypersonic-flow phenomena.

His slides also showed that Mach 15 was possible if the flow was limited to a laminar boundary layer, and in this case the heat effects may be offset by radiation effects.

Various methods of obtaining hypersonic data and their limitations also were discussed. Special notice was made of the difficulties encountered in obtaining and observing hypersonic flow in the wind tunnel, such as cooling systems, balancing, and optical systems.

FRED S. DUNNING
*Corresponding Secretary*

### University of Alabama

Plans for the IAS picnic were discussed at the April 12 meeting. Karl Ball was appointed to take charge of food; Fred Boesche, recreation; and James Nichols, finances.

Chairman William Caudle introduced John Hassler, an IAS student member who is campaigning for the Engineering Legislature.

Karl Ball, who will represent the University of Alabama at the Southwestern Student Conference sponsored by the Texas Section in Dallas, presented a preview of his paper, entitled "Flow Visualization at Low Reynolds Numbers in a Smoke Tunnel."

One of the problems of aerodynamics is the invisibility of the air. For flow studies, some means of observing the flow pattern is needed. Two methods of observing flow patterns are in use. One makes use of small particles which reflect light. These small particles are injected into the air stream

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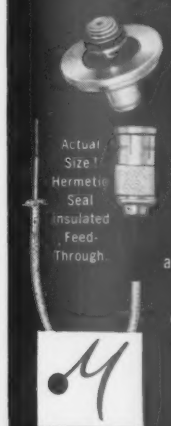


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**ELECTRA (1934):**

**One of the first all-metal passenger planes. Howard Hughes flew one around the world in 1938.**

O

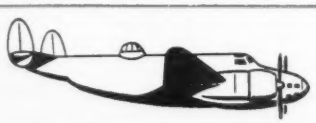
**HUDSON (1938):**

**First American-made plane to fight in World War II. First plane to capture a submarine.**

C

**LODESTAR (1939):**

**Fastest pre-war commercial transport. Served during war as troop, cargo and litter carrier.**



K

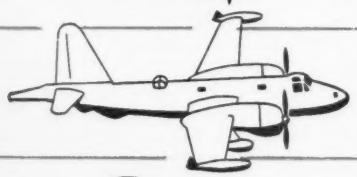
**VENTURA (1942):**

**Versatile hit-and-run bomber of World War II. Backbone of Navy's Pacific air striking force.**

H

**CONSTELLATION (1943):**

**First used as high-speed Air Force transport. Now used by airlines all over the world.**



E

**NEPTUNE (1945):**

**Navy's first land-based patrol plane carries bombs, torpedoes, mines. Also operates from carriers.**

E

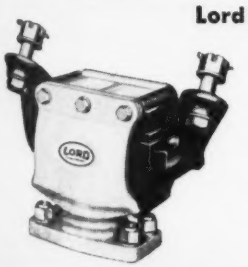
**SUPER CONSTELLATION (1952):**

**Ultra-modern passenger plane. Also used as high-altitude radar plane for Air Force and Navy.**

D

**HERCULES (1953):**

**Aerial freighter. Turboprop powered for high speeds, can carry 20-ton payload.**



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and must be light enough so that they will follow the air stream. The second method is to make use of the change in refractive index due to changes in density of the air.

Mr. Ball used the first method. The smoke, which was generated by a device using cigarettes as fuel, was introduced into the air stream by a rake. A vacuum cleaner was used to power the wind tunnel. Mr. Cornish of Mississippi State was credited with the original design of the tunnel.

Experiments were conducted using a right circular cylinder, an airfoil (Clark Y), and a flat plate. The flow patterns were photographed, and slides were made.

Five slides were shown: (1) flow around a circular cylinder, (2) flow around a rotating circular cylinder, (3) flow around an airfoil, (4) flow around an airfoil with suction applied for boundary-layer control, and (5) flow around a flat plate.

Following the slides, Mr. Ball gave a demonstration of the smoke tunnel.

▸ At the March 8 meeting, C. H. Bryan outlined plans for the IAS Southeastern Student Conference in Atlanta. Lockheed Aircraft Corporation, he said, will give the students a tour of the Marietta plant.

Hubert Davis, Chairman of the Promotion Committee for the Alabama Educational Festival, discussed some of the promotion plans. The Festival is run each spring to attract high school students to the University of Alabama campus and acquaint them with college life.

In the past, there have been many fine Festivals but not enough visiting students. Mr. Davis suggested that this year University students visit their home-town high schools during the spring vacation to explain the purpose of the Festival and urge the high school teachers and students to participate. Several members volunteered to visit their schools.

Two new members, James D. Phillips and Ellison Marlar, were enrolled in the Institute at this meeting.

The program closed with a movie, *Pilot Familiarization of the B-47*.

JAMES O. NICHOLS. *Secretary*

## University of Florida

The April 16 meeting was occupied with a discussion of coming events, including the IAS Student Paper Competition. Guy Logan, Ed Hecker, and Arnold Wolff will represent the University of Florida at the Southeastern Student Conference, sponsored by the Atlanta Section of IAS.

The Nominating Committee, comprising James Bockler, John Stroum, Frank Castellon, and Wayne Clark, will propose a slate of new officers for election on May 7.

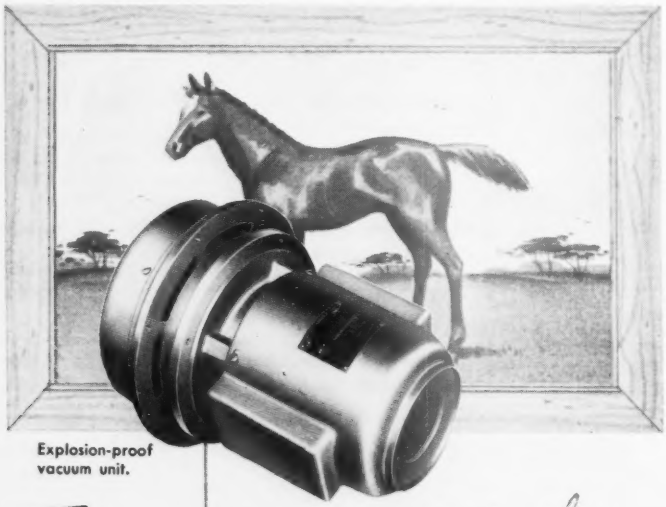
The Student Branch is sponsoring Arnold Wolff as a candidate for President of the Benton Engineering Council and Ed Hecker for Vice-President. The Council's annual Field Day will be held May 5.

Mr. Leonard continued the IAS project of Static Lift by reporting on the "Change-of-Momentum Method." His talk dealt with the functions and characteristics of static-lift devices such as the Magnus rotor, Lippisch's gyrodyne, the Custer channel wing, and the ornithopter.

In line with our campaign to further the prestige of the Aeronautical Engineering Department on the campus, we are inviting all interested students to attend the IAS meetings when we have a visiting lecturer.

▸ Plans for the Honors Night Dinner and the IAS Picnic were discussed at the April 3 meeting.

A 45-min. film, *We Saw It Happen*, was shown. The late Glenn L. Martin, Eddie Rickenbacker, and other aviation pioneers took part in the narration. The story traced the development of aviation from 1903 through World War I, the barnstorming days of the 1920's,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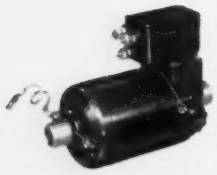
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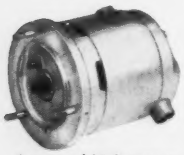
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JOHN DAVID ANDERSON, *Secretary*

### University of Illinois

Frederick H. Green, of AiResearch Manufacturing Company, spoke on "Survival at High Altitudes" at the March 13 meeting.

Some of the high-altitude problems begin right on the ground, one of them being the cooling of the cabin. The temperature in the cockpit of a jet fighter may rise to 165°F. just from radiation and heat convection from the electronic gear while the plane is still on the ramp. Mr. Green showed how a simple cross-flow heat exchanger and turbine can keep the cabin temperature at 40°F. whether the engine is operative or not.

With the help of standard atmosphere and speed-temperature charts, the audience was able to follow Mr. Green in his discussion of how problems of air pressure, cooling, air speed, and lift increase as man pushes higher and higher into the atmosphere. Problems of space travel were discussed briefly.

The Treasurer's report showed that 78 new members had joined the Student Branch during the spring semester.

▸ Two films loaned by The Glenn L. Martin Company were shown at the March 6 meeting: *From Box Kites to Guided Missiles* and *The Martin Matador*. The scheduled speaker was grounded by bad weather, disappointing an audience of 110 students.

▸ The speaker at the February 22 meeting was Richard R. Heppe, Head of the Aerodynamics Department, Lockheed Aircraft Corporation, Burbank, Calif. Mr. Heppe's talk was on the "Design of the Modern Transport Aircraft" and was illustrated by slides. Special reference was made to Lockheed's turboprop transport plane, the Electra.

A large aircraft company cannot neglect the transport field, Mr. Heppe said, because passenger traffic is growing at a fast rate. Many air lines expect to increase their carrier capacity by 15 per cent each year for the next 10 years. If broken down into passenger miles per day, the prevalent short hops over long runs can be seen clearly.

Since many runways are les than 5,000 ft. in length, Lockheed has designed the Electra to fit these conditions. The wing area is comparable to that of the present DC-6, while the fuselage has been changed slightly for passenger comfort. Other features of the airplane include fold-in landing ramps with the door and a baggage space on deck in the forward part of the airplane.

Performancewise, the Electra was not designed to compete with the DC-8 and


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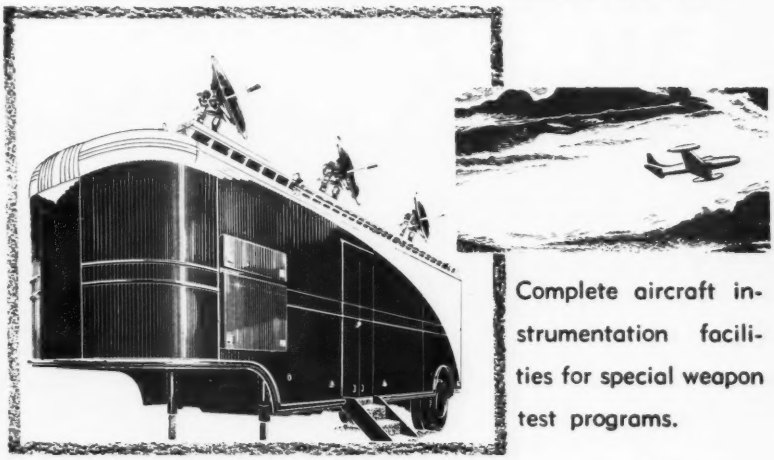

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# World's Fastest Jet

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The *Starfighter's* dart-like configuration, perfected by extensive wind-tunnel tests, permits the F-104 to flash through the sonic barrier, routinely, without a tremor. And even at supersonic speeds the *Starfighter* has unmatched ease and decisiveness of control—because never before have so many advanced design and engineering features been so superbly combined in one aircraft.

Like all Lockheed-built planes, the *Starfighter* has inherent "design flexibility" that makes it readily adaptable to a variety of military requirements—at lowest cost to our government.

Lockheed's leadership in the design and production of military planes, of nine widely different types, stems from its policy of close cooperation with the armed services. In the F-104 *Starfighter* the U. S. Air Force has the world's fastest and deadliest jet—America's "Missile With a Man in It."

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LOOK TO LOCKHEED FOR JET LEADERSHIP, TOO

# LOCKHEED'S NEWS COLUMN

**Dick Tracy has lost his lead** *in the electronics race. His wrist radio is surpassed by a new "miniaturized" TV camera. Small enough to fit into a vest pocket, its "eye" is about the size of a cigarette. Built by Lockheed for research ONLY . . . (so far) . . .*

**Missile Mail** is promised in the foreseeable future as a civilian development of missile technology. A Lockheed official says that the thousands of scientific and technical people now researching the whole environment of man in connection with missile development will produce civilian benefits beyond the imagination of the layman today. A letter by missile, of course, would get there faster than you could write the letter in the first place . . .

**A Lockheed Man** is working quietly in a sanctuary abroad on a nuclear engine design that will make headlines world-wide when they take the wraps off. Same man's blueprints on a nuclear contraption so startled top military authorities very early in the nation's atomic program that they locked his patent in a government vault where, for security reasons, it still remains . . .

**Lockheed has been handed** *a big piece of the much-talked-about ICBMissile that will keep its Missile Systems Division scientists working nights in their new facility near Stanford University — which, incidentally,* **tripled** *in size between blueprints and ground breaking . . .*

**Beating the heat** which tops 250 degrees Fahrenheit at twice the speed of sound is a matter of concern now to engineers of Lockheed's California Division who are working on methods of making airplane skin glass-smooth. Even modern, high-strength dural surfaces approach their temperature limits at these speeds . . .

**Early America** makes atomic history this month as Lockheed Georgia Division breaks ground for its new atom-powered plane facility. The 10,000-acre North Georgia site was in the same family ever since the area opened for settlement in the 1840's.

the Boeing 707 turbojet but rather to be a short-haul, economical, comfortable passenger transport. Mr. Heppe concluded with the statement that passenger transports are definitely a big business and that Lockheed hopes to sell about 1,500 Electras before this line is discontinued.

Two Lockheed films were shown. One was entitled *Progress in 1955* and highlighted progress on the Electra, as well as unclassified military projects. The other, entitled *The F-94C Rocket Launcher*, included some interesting high-speed camera shots.

The following officers have been elected for the spring semester: Chairman, Joseph J. Voda; Vice-Chairman, Roger P. Mueller; Secretary, Fred O. Martikan; and Treasurer, S. V. Drum. Francis H. Bergonz and Harry D. Allen were named Representatives to the Engineering Council.

FRED O. MARTIKAN, *Secretary*

### University of Kentucky

Nine members of this Student Branch and the Faculty Adviser attended the Southeastern Student Conference sponsored by the Atlanta Section of the IAS at Georgia Institute of Technology.

Tom Clore, who represented the University of Kentucky, won first prize in the graduate division. His paper was entitled "The Continuous Disreefing of Parachutes." He discussed the disreefing device developed at the University of Kentucky Aeronautical Research Laboratory. Mr. Clore has been project engineer on this experimental work since it began.

The following officers have been elected for next fall: Chairman, William Privett; Vice-Chairman, Leonard Bennett; Secretary, Alvin Wittwer; and Treasurer, Jesse Ryles.

WALTER J. BLACKSON, *Secretary*

### University of Michigan

Six new members joined the Student Branch at the April 10 meeting. Discussion centered on the advantages of being a student member of the IAS.

A committee headed by Vice-Chairman Lascody was appointed to pursue the Flying Club project.

Stan Smith has completed his paper on "An Atomic-Powered Ram-Jet" for entry in the IAS Student Paper Competition.

A Faculty-IAS picnic was held in May.

FRED STEGENGA, *Secretary*

### University of Oklahoma

Forty members and guests attended the March 6 meeting, with Emmett Fry presiding.

The candidates for Engineering Queen of the University were introduced. Several of the Chi Omega sorority sisters presented a skit.

Jim Maupin and James Biggers were elected Cochairmen of the Open House to be held in April. It was decided to make "The History of Aviation" the theme of the Aeronautical Engineering display.

THOMAS B. SHOEBOTHAM, *Secretary*

### The University of Tulsa

Allen White is in charge of arrangements for the IAS spring picnic.

Three films were shown at the April 12 meeting:

*Nike*—This film on the ground-to-air missile was borrowed from Douglas Aircraft Company, Inc., Tulsa, Okla.

*The AD-4 Skyraider in Korea*—Also borrowed from Tulsa Division of Douglas.

*Machining of Titanium*—Loaned by Pratt & Whitney Company, Inc., West Hartford, Conn.

GEORGE MURRAY, *Vice-Chairman*

▶ At the March 15 meeting, ten displays to be exhibited in the Engineering Open House were demonstrated and explained by the IAS members who prepared them. The displays were:

*A miniature high-speed wind tunnel* to illustrate compression and expansion shock waves.

*Classroom wind tunnel* (velocity 120 m.p.h.) illustrating pressure distribution vs. angle of attack on a model airfoil.

*Tufted-airfoil wind tunnel* to show pressure and boundary-layer distribution vs. angle of attack.

*Partially disassembled engine* to show construction.

*Operating engine with Plexiglas cover plates* to show engine operation and ignition timing.

*Oscilloscope* registering stresses by electrical strain-gage resistance measurements.

*Smoke tunnel* illustrating airflow at low speeds, with variations in boundary layer and turbulence.

*Design drawing* showing parts, subassemblies, assemblies, and airplanes.

*Sample calculations of design problems*—aerodynamic, structural V. N. diagrams, vibration and flutter.

*Disassembled J47 gas-turbine engine* showing construction and operation.

DALE HANNAFORD, *Chairman*

### University of Utah

Chairman Gary Flandro, a senior engineering student, spoke on "The History and Basic Principles of Gliders and Sailplanes" at the March 5 meeting. He mentioned the failures and successful attempts of pioneers in the art of flying, explaining in some detail the construction and flight characteristics of early gliders.

We were interested to learn that the first glider flight by an American was made in California in 1884. The present altitude record for motorless craft (sailplanes) is 33,500 ft., and the distance record is 535 miles.

It is the general opinion of this Student Branch that an opportunity should be given to more senior students to speak on subjects embracing their interests, or in which they have had experience.

DONALD WILKINSON, *Secretary*

### University of Virginia

The Student Branches of the IAS and ASME held a joint meeting March 26 to hear Robert J. Beale, a Design Engineer of The Glenn L. Martin Company, speak on Project VANGUARD.

The VANGUARD three-stage rocket will propel the "basketball" satellite into its orbit around the earth during the International Geophysical Year. This satellite will carry instruments to tell scientists more about the upper atmosphere.

Mr. Beale's talk was followed by a movie about the Martin Viking rocket, entitled *Horizons Unlimited*.

The IAS Middle Atlantic Student Conference, which was held at the University of Maryland in April, will be held here next year.

ALLAN D. SUMMERS, *Secretary*

### University of Washington

Seventy-five members of the Student Branch toured Boeing Airplane Company's wind-tunnel facilities on the evening of March 28. The tour followed a dinner in the plant cafeteria.

The visitors were divided into groups of a dozen members, and each group was conducted by a Boeing wind-tunnel engineer. Robert Joppa and Robert Street of the University faculty accompanied the students. The point of greatest interest was the 8 by 12-ft. transonic tunnel, with its automatic control panel for recording test data. Shock waves were made visible on a schlieren apparatus.

The University's Engineering Open House took place April 6 and 7. The theme of the Aeronautical Engineering Department was "Supersonic Transportation" and the various displays and exhibits illustrated the problems of supersonic flight: flutter, physiology of high-speed flight, aerodynamic heating, stability and control, propulsion, and landing and take-off. Edward Westwood, senior aeronautical engineering student, received a gold cup for the

(*Continued on page 101*)

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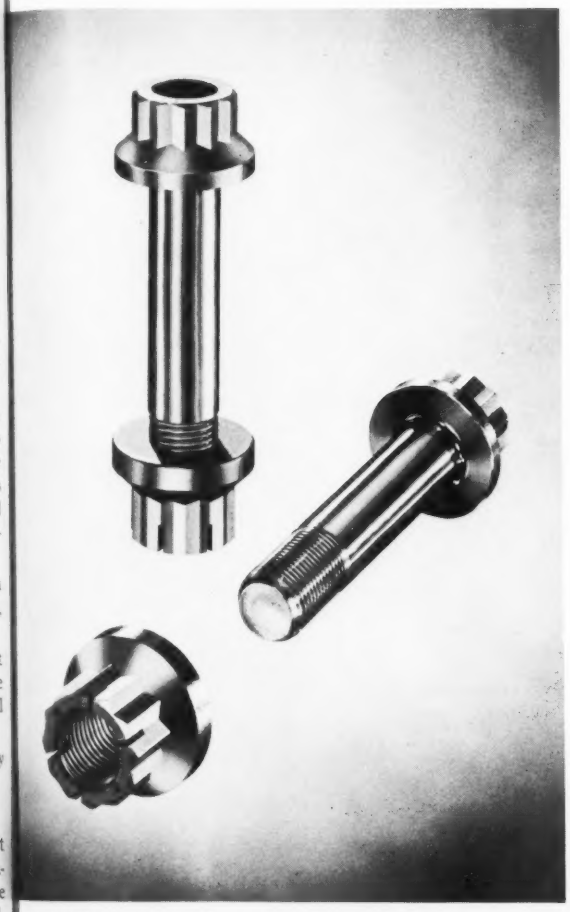

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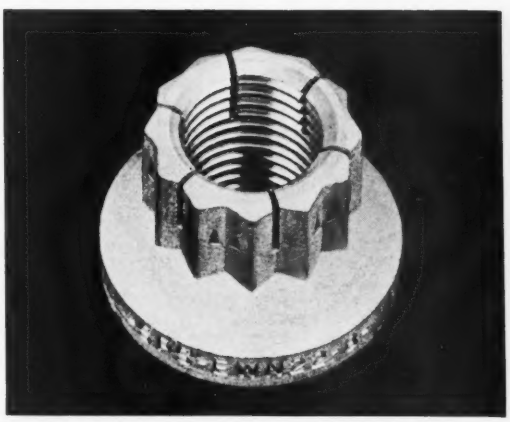
**Hi Psi units . . . results of advanced concepts in thread design and preloading techniques . . . add strength, security and weight saving to aircraft structures**

Conventional bolts were not strong enough to fasten jet-age aircraft now on drawing boards. So Standard Pressed Steel Co. discarded obsolescent fastener conformations, materials and production techniques and designed a new high strength bolt—the Hi Psi EWB-22 —which has greater tensile and fatigue strength than ever believed possible.

But it is impossible to get the full benefit of the strength of any bolt unless it is preloaded accurately. PLI washers, simple mechanical devices for preloading, insure that every Hi Psi bolt installed in an airframe will carry its full share of the load.

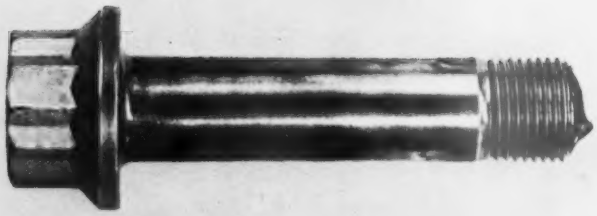
Conventional nuts were not strong enough to develop the full strength of the EWB-22. So SPS produced the EWN-22 locknut to complement the bolt. It is a high tensile strength self-locking nut with a 12-point external wrenching surface which makes possible the high wrenching torque necessary to seat the EWB-22 securely.

**Compared with standard 160,000 psi bolts, at 8,000,000 cycles.*



**EWN-22 Locknut** was designed to develop the full strength of the EWB-22 bolt. One-piece, all-metal nut has increased bearing surface, is specially heat treated for maximum tensile strength, has 12-point external wrenching surface for high wrenching torque.

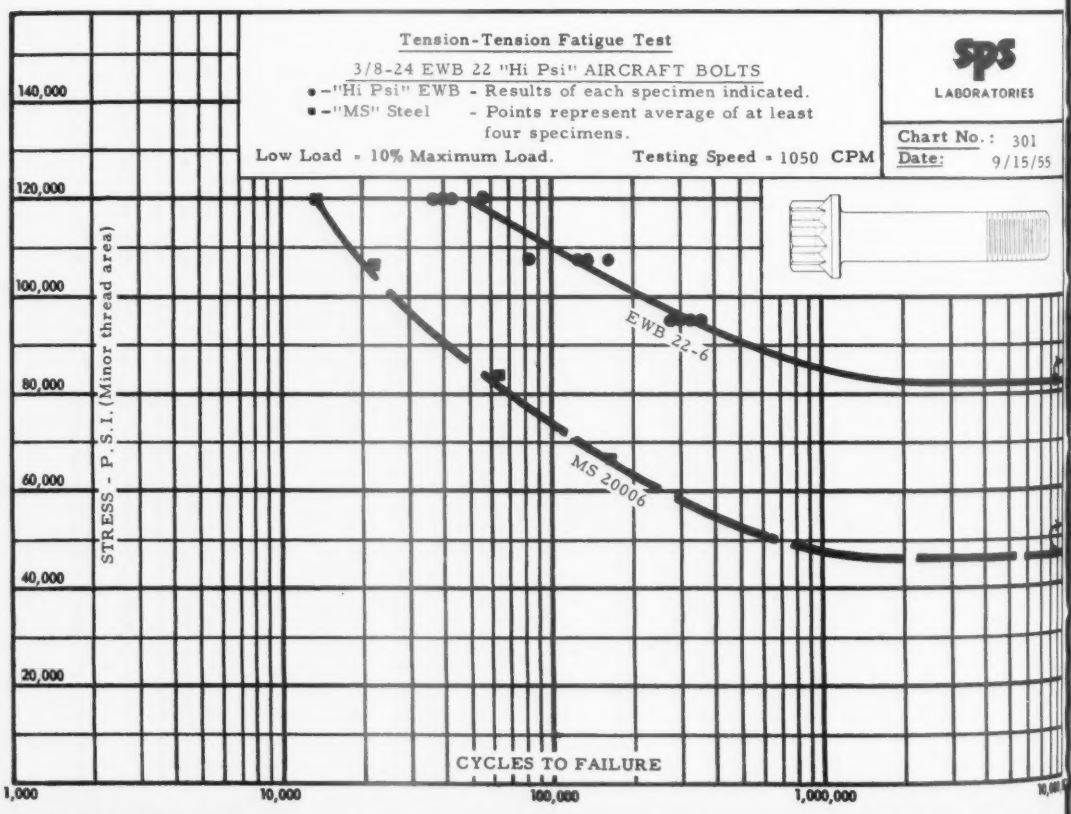
# New Hi-R Thread Form is Key to Great Fatigue Resistanc



**EWB-22 Bolt Stressed to Destru-tion** in SPS fatigue testing labor-tory. Typical fracture occurred i vicinity of nut bearing face.

The EWB-22 has 38% greater tensile strength and up to 90% greater fatigue strength than its strongest standard counterpart, the MS bolt. The high strength of the bolt is due partly to the new alloy steel of which it is manufactured, partly to the generous fillet under the head, and partly to the fact that the threads are cold rolled *after* the blank has been heat treated and ground smooth to remove all surface imperfections and decarburized metal.

But the chief factor in the great fatigue resistance of the EWB-22 is the new Hi-R thread form developed at SPS. Normally, the thinnest—and hence weakest—part of a bolt is the minor diameter of its threaded section. The Hi-R thread form increases this dimensio by 1.5 to 3.2% (depending upon bolt size). In additio the thread root radius has been increased. This roo radius is not a "worn tool arc," but a smooth uniform curve which fairs smoothly to the thread flanks, at th point of 75% thread depth, with an uninterrupted surface. (Existing gages, designed for 83⅓% threa engagement, must be opened to accommodate th EWB-22. However, the thread will assemble readil with standard nuts, since the basis of the thread desig is the 60° American National Thread profile.) The uni form radius reduces stress concentration factors, in creasing fatigue resistance to a maximum.



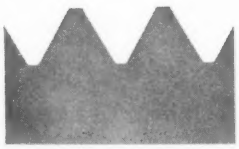

**Typical Stress-Cycle Curve,** comparing performance of EWB-22 with that of MS tension bolt of equal size. The EWB-22 shows up to 90% greater fatigue strength than the MS bolt.

**Ultimate Tensile Strength Curves.** Chart shows actual strength in pounds plotted against bolt diameter. Great strength in EWB-22 derives from SPS material selection, forming, and heat treating techniques.

## MECHANICAL PROPERTIES

| | ⅜-24 Diameter | | ½-20 Diameter | |
|---|---|---|---|---|
| | MS20006 | EWB 22-6 | MS20008 | EWB 22-8 |
| **Tensile strength—psi** | | | | |
| Root thread area | 192,800 | 281,000 | 199,900 | 266,600 |
| Mean thread area | 178,100 | 260,300 | 186,000 | 248,100 |
| Pitch thread area | 164,000 | 239,750 | 172,900 | 230,600 |
| Bolt gage specimen* | 170,000 | 237,200 | 174,400 | 235,200 |
| **Yield strength—psi** | | | | |
| Root thread area | 155,750 | 229,900 | 171,600 | 217,000 |
| Mean thread area | 143,840 | 212,300 | 159,700 | 201,900 |
| Pitch thread area | 132,500 | 195,600 | 148,400 | 188,700 |
| Bolt gage specimen* | 148,000 | 202,000 | 158,700 | 211,000 |
| **Elongation—% in 4 dia.** | | | | |
| Bolt gage specimen* | 14.5 | 12.5 | 15.6 | 13.5 |
| **Reduction in area—%** | | | | |
| Bolt gage specimen* | 52.4 | 51.2 | 56.6 | 49.3 |
| **Shear strength—psi** | | | | |
| Bolt body | 100,200 | 138,250 | 106,200 | 137,500 |
| **Fatigue strength—pounds at 8,000,000 cycles** | | | | |
| 10% preload | 3,500 | 6,750 | 7,850 | 11,180 |

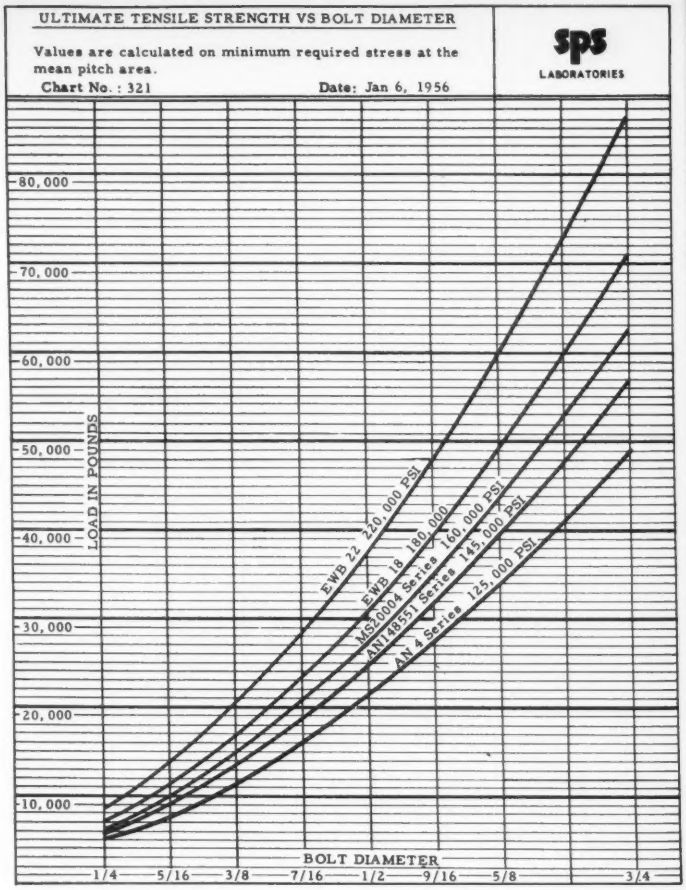
*Bolt gage specimens are gage specimens made from the bolts being tested. The gage diameter on the ⅜ inch was .252 inch and on the ½ inch was .357 inch.

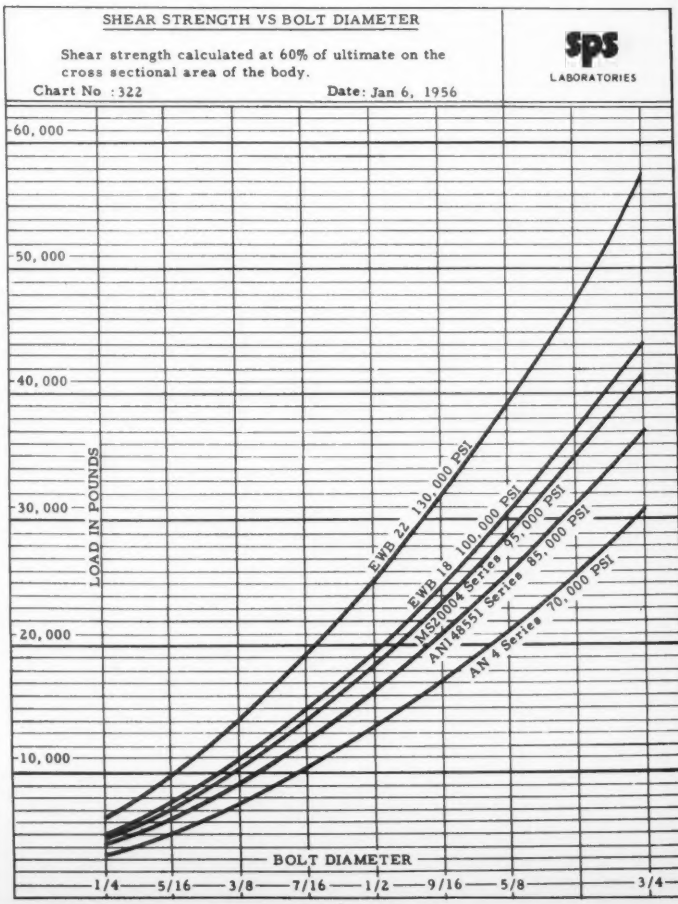


**Unretouched Comparator Photograph** of MIL-S-7742 thread. Flat thread roots with small radii cause points of high stress concentration which reduce fatigue life.

**MIL-S-7742, MIL-B-7838a Threads.** Larger (.0065 in.), more uniform radius reduces stress concentration, increases fatigue life.

**H-R Thread Form.** Increased root radius (.009 in.) reduces stress concentrations still further for greater increase in fatigue resistance. Thread assembles with standard tapped holes and nuts.



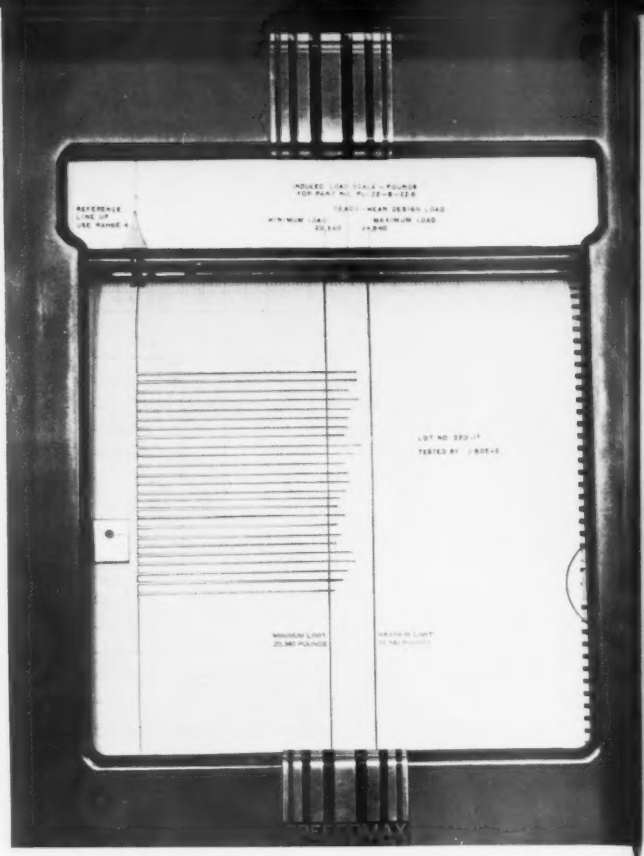

**Shear Strength Curves,** plotted at 60% of the ultimate, based on body cross section area. Second strongest bolt is EWB-18, also developed by SPS.

## New EWN-22 Nut . . .
## Preloaded with PLI Washers . . .
## Develops Full Strength of Bolt

The EWN-22 self-locking nut equals the EWB-22 bolt in fatigue strength. The load is distributed over more metal threads than in conventional fasteners. And increased dimensions—in thickness of base and washer face, and area of bearing surface—help reduce stress concentrations to a minimum.

Assembling Hi Psi-22 fasteners is a simple operation. The nut is tightened down until the outer PLI ring can no longer be rotated by a wire inserted in a feeler hole. No complex electronic equipment, no unreliable torque wrench readings. Only strain gage or extensometer measurements—not feasible in production operations—exceed PLI washers in accuracy.

Detailed information on Hi Psi fasteners will be gladly sent on request. Write Aircraft Products Division, STANDARD PRESSED STEEL CO., Jenkintown 58, Pa.



**Strain Gage Measurements,** electronically recorded, show that preloading with PLI washers is accurate within ±10%. Preloading by torque wrench readings varies as much as 50%.

**Before Preloading.** Inner PLI ring has not been compressed. Outer PLI ring can be rotated freely by wire in feeler hole. Nut is then tightened until outer ring cannot be rotated.

**After Preloading.** Nut has been tightened down fully. Inner PLI ring has been plastically deformed by compression. Preload in bolt equals force required to deform inner ring.

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**Members of the IAS Student Branch at the University of Washington, 1955–1956, photographed at a meeting in Seattle this spring.**

best individual presentation of a display.

GILBERT LEE
*Corresponding Secretary*

### University of Wichita

At the March meeting, Gordon Leuson, a graduate student, presented a paper which he is entering in the Southwestern Student Paper Competition sponsored by the Texas Section at Dallas. The subject of his paper was "Flutter in a Two-Dimensional Airfoil."

Mr. Leuson described the results of tests run in the University's 4-ft. wind tunnel. A small airfoil of approximately 1-ft. span and 2-ft. chord was mounted on spring-steel flexures in the tunnel. The airfoil had a control surface which also was supported by steel flexures. Vibrations were measured at various speeds by accelerometers placed in the model. The results were plotted and compared to theoretical data.

DUANE CHICHESTER, *Secretary*

### Virginia Polytechnic Institute

R. W. Truitt, Head of the Aeronautical Engineering Department, discussed the forthcoming IAS Student Paper Competitions at the March 6 meeting.

V.P.I. will be represented by three student papers at the Southeastern Conference sponsored by the Atlanta Section of IAS at Georgia Institute of Technology, and by two student papers at the Middle Atlantic Conference at University of Maryland. Three members plan to make the trip to Atlanta, and 13 will attend the meeting in College Park, Md.

Richard T. Whitcomb, MIAS, current winner of the Collier Trophy, has agreed to speak at the Aeronautical Engineering Symposium during Engineering Emphasis Week, April 23–28. Mr. Whitcomb discovered the "area rule" in NACA's 8-ft. transonic wind tunnel at Langley Aeronautical Laboratory.

Bill Grossman has been elected Junior Representative to the Engineering Advancement Council.

GEORGE E. POWELL, *Secretary*

### Wayne University

The February 23 meeting was largely a planning session to develop future programs. For the benefit of new members, Chairman Joe Kochevar introduced the other officers: George Byberg, Vice-Chairman; John Rausch, Treasurer; and Edward Coleman, Secretary. He also introduced Joseph Rutkowski, MIAS, Faculty Adviser, and Arthur A. Locke, AFIAS, Head of the Department of Aeronautical Engineering.

A discussion of plans for the semester placed considerable emphasis on the need for work on the Engineering College's first annual open house—The Engineering Showcase. Purpose of the Showcase is to introduce the public and surrounding industries to Wayne University and the facilities available here.

Cochairmen of the Aeronautics Department for the Showcase are Jury Lewizky and Edward Coleman. They discussed the need for accelerated effort on the part of all IAS members if the projects under consideration were to be constructed by the April deadline. Plans for the current semester also placed emphasis on the annual Regional Student Paper Contest.

A report was heard from the newly organized Freshman Orientation Committee. The purpose of this committee is to assist young men in starting their college careers and to inform them regarding the facilities available.

Professor Locke introduced R. Craig Fabian, Industrial Relations Officer for the Naval Air Turbine Test Station at Trenton, N.J. He spoke of the need for engineers and the salaries that can be expected in industry.

Following his address, the meeting was closed with the showing of a film, *Piercing the Unknown*, which dealt with electronic calculating machines.

EDWARD COLEMAN, *Secretary*

## MEMBERS ELECTED

*The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the Review.*

### Elected to Associate Fellow Grade

**Coe, Charles F.,** B.S., Vice Adm., USN (Ret.); Asst. to V-P (Wash., D.C.), Ryan Aeronautical Co.

**Craigie, Laurence C.,** B.S., Lt. Gen., USAF (Ret.); V-P, Hydro-Aire, Inc.

**Furth, Frederick R.,** M.S., Rear Adm., USN (Ret.); V-P, R&D, International Telephone & Telegraph Corp., Farnsworth Electronics Co.

**Ritter, William K.,** M.E., Asst. Chief, Compressor & Turbine Research Div., Lewis Flight Propulsion Lab., NACA.

**Vieweg, W. V. R.,** B.S., Rear Adm. USN (Ret.); Asst. Chief, R&D Engr., Electric Boat Div., General Dynamics Corp.

**Yeates, John E., Jr.,** B.S., Aero. Research Scientist, Proj. Engr., Langley AFB, NACA.

### Transferred to Associate Fellow Grade

**Attinello, John S.,** M.A.E., Asst. Chief—Research, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

**Clegern, William A.,** B.S.M.E., Mgr.—Marketing, Jet Engine Dept., General Electric Co. (Cincinnati).

**Cohen, Clarence B.,** Ph.D., Assoc. Chief, Special Proj. Branch, Lewis Flight Propulsion Lab., NACA.

**Cooper, George E.,** B.S. Mining Engrg., Chief Aero. Research Pilot, Ames Aero. Lab., NACA.

**Cortright, Edgar M., Jr.,** M.S. in Ae.E., Aero. Research Scientist—Aerodynamics; Chief, 8- × 6-Ft. Supersonic Tunnel Branch, Lewis Flight Propulsion Lab., NACA.

**DeLauer, Richard D.,** Ph.D. (*cum laude*), Lt. Comdr., USN; Military Staff

Member; Head, Design Sect., Engrg. Design Group, Propulsion Div., Los Alamos Scientific Lab.

**DeLorenzi, Ezio P.,** Ae.E., Proj. Struct. Engr., Preliminary Design Group, Bell Aircraft Corp.

**Denke, Paul H.,** M.S., Strength Analysis Methods Engr., Douglas Aircraft Co., Inc. (Santa Monica).

**Eggers, Alfred J., Jr.,** M.S. in Engrg. Sc., Chief, Supersonic Wind Tunnel Branch, Ames Aero. Lab., NACA.

**Etkin, Bernard,** M.S. in Ae.E., Assoc. Prof.—Aero. Engrg., Research Assoc., Institute of Aerophysics, Univ. of Toronto.

**Gillespie, Warren, Jr.,** M.S. in Ae.E., Aero. Research Scientist, Stability & Control Branch, Langley AFB, NACA.

**Gwathmey, Edward S.,** Ph.D. in Physics, Dir.—Research, Specialities, Inc.

**Hasert, Chester N.,** M.S. in Ae.E., Technical Dir., Scientific Advisory Board, Hq. USAF (Wash., D.C.)

**Hayes, Wallace D.,** Ph.D., Assoc. Prof.—Aero. Engrg., Princeton Univ.

**Low, George M.,** M.S. in Ae.E., Chief, Special Proj. Branch, Lewis Flight Propulsion Lab., NACA.

**Maslen, Stephen H.,** Ph.D., Member, Applied Mech. Group, Lewis Flight Propulsion Lab., NACA.

**Morrell, Gerald,** M.S.E. (Chem. Engrg.), Head, Rocket Combustion Sect., Lewis Flight Propulsion Lab., NACA.

**Ostrach, Simon,** Ph.D. in Applied Math., Chief, Applied Mech. Branch, Lewis Flight Propulsion Lab., NACA.

**Passman, Richard A.,** M.S.E. (Ae.E.), Proj. Aerodynamicist, Bell Aircraft Corp.

**Roshko, Anatol,** Ph.D. in Aero., Asst. Prof.—Aero., California Institute of Technology; Consultant, Lockheed Systems Div.

**Stone, Ralph W., Jr.,** M.S. in Ae.E., Asst. to Chief—Stability, Research Div., Langley Aero. Lab., NACA.

**Weinig, Friedrich S.,** Dr.Ing., Aerodynamicist, AGT Div., General Electric Co.

## Elected to MEMBER Grade

**Berry, James G.,** Ph.D., Member—Tech. Staff, Aeromech. Sect., Guided Missile Research Div., The Ramo-Wooldridge Corp.

**Bond, Edward L.,** B.S.M.E., Sr. Design Engr., Lockheed Aircraft Corp. (Marietta).

**Burley, Richard R.,** B.S. in M.E., Aero. Research Scientist, NACA (Cleveland).

**Byron, Raymond A. V.,** B. of Engrg., Design Engr., Commonwealth Aircraft Corp. (Australia).

**Epple, Heinrich K.,** Dipl.Eng., Chief Engr.—R&D, Irving Air Chute Co., Inc.

**Eriksen, John G.,** B.S., Col. USAF; Deputy Comdr., Air Tech. Intelligence Center, Wright-Patterson AFB.

**Harrin, Eziaslav N.,** B. of Ae.E., Aero. Research Scientist, General Aerodynamics Branch, Flight Research Div., Langley Aero. Lab., NACA.

**Harris, Thomas S.,** Experimental Test Pilot, McDonnell Aircraft Corp.

**Henshaw, Sydney H.,** Sr. Draftsman, The Bristol Aeroplane Co., Ltd. (England).

**Hnatiuk, Bohdan T.,** Dr.Ing., Assoc. Prof., Univ. of Notre Dame.

**Holzapfel, Harrison W.,** Staff Engr.—Transport System, AiResearch Manufacturing Co.

**Irwin, Horace G.,** A.B., Struct. Group Engr., Douglas Aircraft Co., Inc. (Tulsa).

**Jacobs, Willi F. H.,** Dr.Rer.Nat.Habil., Aero. Engrg. Scientist—Proj. & Research, Lockheed Aircraft Corp. (Marietta).

**Kronauer, Richard E.,** Ph.D., Asst. Prof., Harvard Univ.

**Kux, Frank W.,** Engrg. Specialist, Marquardt Aircraft Co.

**Landgraf, Stanley K.,** B.S. in Ae.E., Aerodynamics Group Leader, McDonnell Aircraft Corp.

**Lindsey, Morris W.,** Capt. USAF; Pilot & Maint. Officer, 1700th Test Sq., MATS, Kelly AFB.

**Matson, Clifford H., Jr.,** B.S., Turbine Air Design Engr., General Electric Co. (Cincinnati).

**Maycock, John C.,** General Supvr., Quality Control Equipment Lab., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

**McManus, H. L., Jr.,** M.S. in Physics, Tech. Engr., General Electric Co. (Evendale).

**Meyer, Carl L.,** B.S., Aero. Research Scientist; Head, Propulsion Systems Lab., Lewis Flight Propulsion Lab., NACA.

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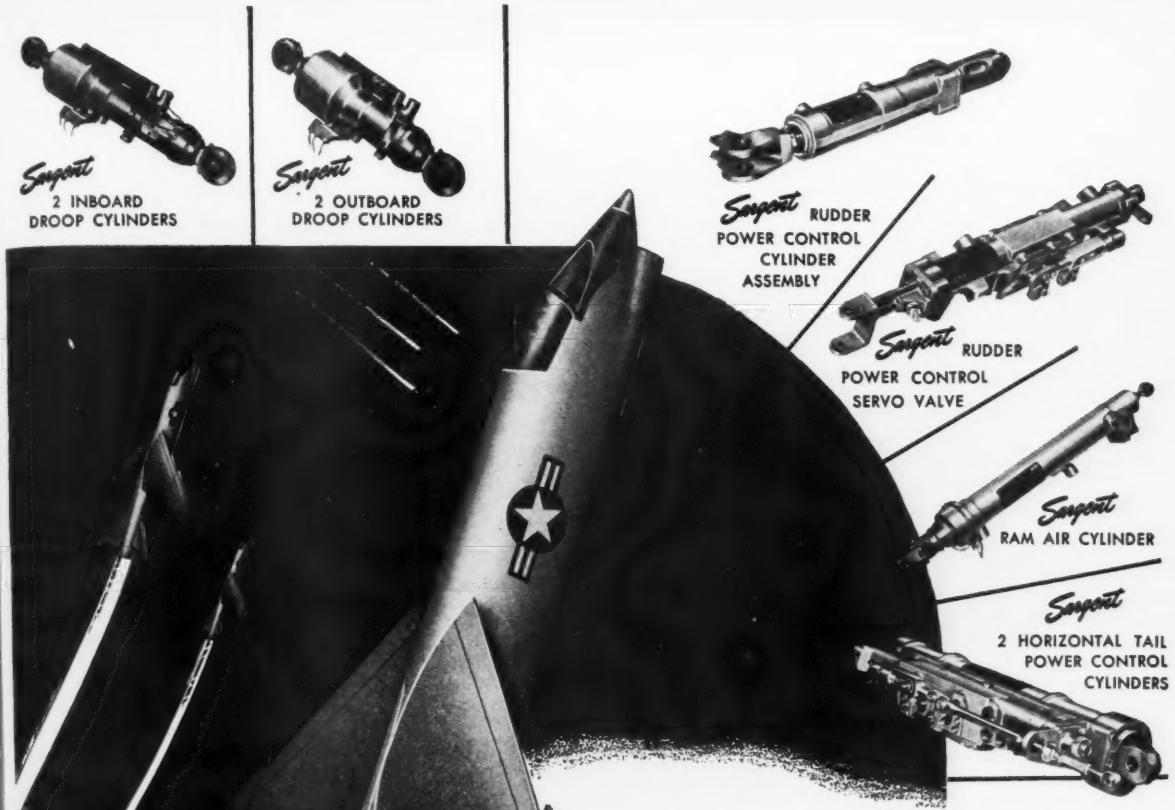
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**Muller, Ragnwald,** M.S. in Bioradiology, Lt. Comdr., USN; Aero. Engrg. Duty & Proj. Officer, Aircraft Reactor Branch, DRD, USAEC, Wash., D.C.

**Norton, Durward H.,** Sr. Engr.—Weights, McDonnell Aircraft Corp.

**Oakley, Robert L.,** Major, USAF; Asst. Chief, Parachute Branch, Equipment Lab., WADC, Wright-Patterson AFB.

**Papirno, Ralph P.,** M.A., Research Assoc. & Assoc. Engrg. Scientist, Research Div., College of Engineering, New York Univ.

**Ray, William A.,** B.S.C.E., Design Engr., Convair, San Diego, A Div. of General Dynamics Corp.

**Ryker, Norman J., Jr.,** M.S., Sr. Engr.—Struct., Preliminary Design Group, Missile Div., North American Aviation, Inc. (Downey).

**Sallen, Eugene G.,** B.S. in Ae.E., Instrumentation Engr. "A," Flight Test Engrg. Div., Lockheed Aircraft Corp. (Burbank).

**Scull, Wilfred E.,** M.S., Aero. Research Scientist, Lewis Flight Propulsion Lab., NACA.

**Spangler, Roman M., Jr.,** B.S. in Ae.E., Flight Test Engr., Flight Research Dept., Sperry Gyroscope Co.

**Tompkins, William M.,** Design Proposal Electronics Engr., Douglas Aircraft Co., Inc. (Santa Monica).

**Valdenazzi, Luigi G.,** Dr. in Mech. & Marine Engrg., Head—Research, Turbomachinery Dept., Ansaldo S.A. Stabilimento Meccanico; Prof., Univ. of Genoa.

**Ward, George H.,** B.S.M.E., Specialist—Aircraft Engines, General Electric Co., (Wichita).

**Watson, Bennie M.,** Dynamics Engr., McDonnell Aircraft Corp.

**Welsh, Harvey W.,** M.S.M.E., Advanced Design Engr., Allison Div., General Motors Corp.

**Westermeier, Theodore F., Jr.,** B.S. in E.E., Engr. "A," Dynamics Dept., McDonnell Aircraft Corp.

**Whitaker, H. Philip,** S.B., Asst. Dir.—Flight Control Program, Instrumentation Lab., Massachusetts Institute of Technology.

**Williams, Sam B.,** B.S., President, Williams Research Corp.

**Woolf, William,** M. of Ae.E., Sr. Engr., The Glenn L. Martin Co.

**Yamaguchi, Shigeyoshi,** B. of Engrg., Sumitomo Metal Industries, Ltd. (England).

## Transferred to MEMBER Grade

**Achitoff, Louis,** M.S. in Ae.E., Asst. to the President, Flight Safety, Inc.

**Bloxson, Daniel E., Jr.,** B.A., Engr.—Engrg. Physics, ARO, Inc.

**Chase, Thomas W.,** B. of Ae.E., Research Engr.; Member, Aircraft Dynamics Group, Aero. Div., Minneapolis-Honeywell Regulator Co.

**Grande, Donald L.,** B.S., Struct. Engr., Cessna Aircraft Corp.

**Henry, James R.,** A.A. in Ae.E., Stress Group Supvr., McDonnell Aircraft Corp.

**Hodge, Kenneth E.,** B. of Ae.E., Dynamics & Control Engr., Research Dept., Grumman Aircraft Engineering Corp.

**Laidlaw, William R.,** Sc.D., Group Leader—Dynamics, North American Aviation, Inc. (Columbus).

**McCarthy, Walter T.,** B.A.E., Wind Tunnel Mgr., Convair, San Diego, A Div. of General Dynamics Corp.

**Miller, Bernard P.,** B.S. in Ae.E., Instructor, Dept. of Marine Engrg., USNA (Annapolis).

**Rupp, George R.,** M.S. in Ae.E., Major Officer—Operations & Maint., USMC.

**Sagata, Juro,** B.S. in Ae.E., Design Engr., Douglas Aircraft Co., Inc. (Los Angeles).

**Svernby, Alf W.,** Civilingenjor, Aerodynamicist, Missile Dept., Royal Swedish Air Board.

**Venesky, Bernard M.,** B.S. in Ae.E., Functional Liaison Engr. "A," Design Group, Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

**Watson, John H.,** M.S. in M.E., Aerophysics Engr., Automatic Controls, Convair, Ft. Worth, A Div. of General Dynamics Corp.

**Weining, Roger F.,** B. of Ae.E., Research Facilities Engr., Lewis Flight Propulsion Lab., NACA.

## Elected to Associate Member Grade

**Biddle, Albert G. W., Jr.,** B.S. Engrg., Operations Engr., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

**Christie, Arthur R.,** Wash. Rep., Pratt & Whitney Aircraft Div., United Aircraft Corp.

**Cushman, Robert H.,** B.S. in Ae.E., Assoc. Editor, McGraw-Hill Book Co., Inc.

**Draper, Joseph W., Jr.,** Chief—Information Services, Continental Div., Military Air Transport Service, Kelly AFB.

**Gesellschap, Robert E.,** Design Engr., McDonnell Aircraft Corp.

**Riddel, Douglas A.,** B.S. Commerce & Economics, Supvr.—Planning & Scheduling, Flight Test Div., McDonnell Aircraft Corp.

**Sargent, Ignatius,** Dir., Flight Environment Div., Electronics Corp. of America.

**Steely, Oscar B.,** B.S., Col., USAF; Deputy Chief of Staff, Comptroller, CNTLD, MATS, National Defense, Kelly AFB.

**Stephens, Richard G.,** B.S.E.E., Patent Counsel, Darby & Darby.

**Thomas, Frank R.,** Analyst, Allison Div., General Motors Corp.

**Voris, E. D.,** Capt., Air-Line Pilot, Trans World Airlines (Kansas City).

## Elected to Technical Member Grade

**Bowman, Robert W.,** B.S.C.E., Struct. Engr. "B," Ryan Aeronautical Co.

**Bullington, Robert H.,** B.S. in Ae.E., Design Engr., Instrument Group, Northrop Aircraft, Inc.

**Clubb, Gordon E.,** Functional Test Engr., McDonnell Aircraft Corp.

**Fehrenbacher, Paul L.,** B.S., Class "C," Engr., McDonnell Aircraft Corp.

**Fleischer, Henry A.,** B.S., Layout Engr., McDonnell Aircraft Corp.

**Gaertner, Reinhold V.,** B.S. Physics, Design Engr., Aero. Div., Minneapolis-Honeywell Regulator Co.

**Hafter, Reuben,** B.S. in Ae.E., Sr. Flight Test Engr., Republic Aviation Corp.

**Hall, John B., Jr.,** B.S., Aero. Research Intern, Langley Aero. Lab., NACA.

**Jourden, Ralph G.,** B.S.C.E., Physical Test Engr., McDonnell Aircraft Corp.

**Kalish, Eva R.,** B.S., Tech. Analyst—Vibration & Flutter, McDonnell Aircraft Corp.

**Kirk, Harry L.,** B. of C.E., Struct. Engr., Fairchild Aircraft Div., Fairchild Engine & Airplane Corp.

**Klosterman, Gerald R.,** B.S., Flight Control Engr., McDonnell Aircraft Corp.

**Kouri, Bobby G.,** B.S., Aerophysics Engr., Convair, Ft. Worth, A Div. of General Dynamics Corp.

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**Zrodlo, Edward M.,** Design Engr., Canadair, Ltd.

## Texas Section's Student Paper Competition

(*Continued from page 18*)

Convair, and Temco plants. Luncheon was provided by Chance Vought.

Saturday evening, the Awards Night Dinner was held in the Roof Garden of the Adolphus Hotel. It was attended by 143 members of the Texas Section and guests, in addition to the students and faculty. Mr. Boucher made the address of welcome and introduced the guests of honor.

These included E. H. Hereford, of Arlington State College; Bartram Kelley, of Bell Aircraft; Comdr. G. C. Burkey, USN, Flight Test Officer, BAR, Dallas; R. C. Blaylock, of Chance Vought; C. J. McCarthy, Chairman of Chance Vought; E. W. Robischon; B. G. Reed, Assistant Division Manager, Convair, Fort Worth; F. W. Davis, of Convair; Robert H. McCulloch, President of Temco; and I. N. Palley, of Temco.

Following the introductions, Mr. Boucher pointed out some highlights of the Student Paper Competition. R. J. Patton, Vice-Chairman of the Texas Section, then introduced the principal speaker, Brig. Gen. Fred M. Dean, USAF, Vice-Commander of the Flying Training Air Force, Waco, Tex.

Speaking on "Effects of High-Altitude Flying," General Dean described the problems that have been overcome in training men to fly during the past 25 years. Despite the increases in speed, altitude, and complexity of aircraft, the length of time required to train a man to fly has not changed much, he said.

The principal problems to be overcome are mostly physiological. He described an interesting piece of aeromedical detective work aimed at solving a series of unexplained fatal accidents. It was found that hyperventilation, brought on by breathing too rapidly and deeply as a result of psychological stress—and thus causing a loss of carbon dioxide—was responsible for the majority of these accidents. The investigation also focused attention on the importance of having an adequate breakfast. Once steps had been taken to institute corrective action, there was a much lower unexplained-accident rate.

Finally came the main event for the contestants—the presentation of awards. The winners in the Undergraduate Division, and their subjects, were: *First Prize*, Richard F. Weick, Agricultural and Mechanical College of Texas, "Preliminary Design of a Turbine-Powered Executive Transport"; *Second Prize*, W. A. Wickstrom, University of Colorado, "Design, Construction, and Testing of a Flexible-Wall Supersonic Wind Tunnel Nozzle"; *Third Prize*, J. M. Cobb, University of Utah, "The Strengthening Effect of Internal Pressure on Thin-Walled Cylinders in Bending."

Winners in the Graduate Division were: *First Prize*, D. T. Higdon, University of Kansas, "Investigation of an 'On-Off' Type Automatic Rudder Control for Light Aircraft"; *Second Prize*, J. T. Kevorkian, Georgia Institute of Technology, "An Approximate Solution for the Streamlines About a Lifting Rotor Having a Uniform Loading and Operating in Low-Speed Vertical Descent Range"; *Third Prize*, G. G. Luessen, University of Wichita, "Two-Dimensional Flutter Studies of a Pressure-Seal Balanced Elevator."

BENJAMIN C. SCOTT, JR.
*Publicity Chairman*
*Texas Section*

# Aeronautical Reviews

*A Guide to the Current Literature of Aeronautical Research and Engineering*

THIS SECTION reviews important periodicals, technical and research reports, and books received in the IAS Library in order to provide basic documentation for engineers and scientists.

INTERNATIONAL AERONAUTICAL ABSTRACTS, published as an insert in each issue, is an accelerated reviewing service covering world-wide scientific and technical literature. This work is performed by the IAS Staff and is supported by the Air Force Office of Scientific Research of the Air Research and Development Command.

A list of the periodicals and reports series received in the IAS Library is published semiannually, in the January and July issues.

The AERONAUTICAL ENGINEERING INDEX, published since 1947, provides an annual cumulation of the materials reviewed in this section.

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These periodicals and reports are maintained in the IAS Library and are made available through its lending, photocopy, and reference facilities. The IAS Library does *not* sell these publications.

## Periodicals

**Acta Polytechnica.** Royal Swedish Academy of Engineering Sciences, Stockholm, Sweden, Irreg.

**Aero,** Herman Lingg Strasse 9, Munich 15, Germany, M, DM 12

**Aero Dig.** Aero Digest, 14th & F Streets, NW, Washington 4, D.C., M, $5

**Aero. Eng. Rev.** Aeronautical Engineering Review. Institute of the Aeronautical Sciences, Inc., 2 E. 64 St., New York 21, N.Y., M, $3

**Aéro France.** Aéro Club de France, 6, rue Galilée, Paris 16, France, M, 1,200 fr.

**Aero Mag.** Aero Magazine (Supplement to Velocidade), Caixa Postal 4917, São Paulo, Brazil, M, Cr$200 (2 years)

**Aero. Quart.** Aeronautical Quarterly. Royal Aeronautical Society, 4 Hamilton Place, London W 1, England, Q, $8.55.

**Aeronautics,** Tower House, Southampton St., Strand, London WC 2, England, M, 33s.

**The Aeroplane,** Bowling Green Lane, London EC 1, England, W, $14

**Aeroporika Nea,** 4 Othonos St., Athens, Greece, M

**Aerovox Res. Worker.** Aerovox Research Worker. Aerovox Corp., New Bedford, Mass., M

**Les Ailes,** 77, blvd. Malesherbes, Paris 8, France, W, 1,200 fr.

**L'Air,** 71 Champs-Elysées, Paris 8, France, M, 1,500 fr.

**Air Facts,** 30 Rockefeller Plaza, New York 20, N.Y., M, $3

**Air Force.** Air Force Assn., Mills Bldg., Washington 6, D.C., M, $4

**Air Line Pilot,** Air Line Pilots Assn., International, 55 St. & Cicero Ave., Chicago 38, Ill., M, $2.50

**Air Pictorial.** Air Pictorial and Air Reserve Gazette. Air League of the British Empire, Londonderry House, 19 Park Lane, London W 1, England, M, £1

**Air Rev.** Air Revue, 11 rue de Crayer, Brussels, Belgium, M, 350 fr. belge

**Air Safety Digest.** Flight Safety Foundation, Inc., 471 Park Ave., New York 22, N.Y., Q

**Air Transp.** Air Transportation, 10 Bridge St., New York 4, N.Y., M, $5

**Air U. Quart. Rev.** Air University Quarterly Review, Maxwell AFB, Ala., Q, $2

**Aircraft.** Royal Aeronautical Society, Australian Division, etc., 26 Flinders St., Melbourne, Australia, M, 30s.

**Aircraft,** 341 Church St., Toronto 2, Canada, M, $5

**Aircraft Eng.** Aircraft Engineering, 12 Bloomsbury Sq., London WC 1, England, M, 35s.

**Aircraft Prod.** Aircraft Production, Dorset House, Stamford St., London SE 1, England, M, $6

**Airports & Air Transp.** Airports and Air Transportation, 92 Victoria St., London SW 1, England, BM, 15s.

**Allis-Chalmers Elec. Rev.** Allis-Chalmers Electrical Review. Allis-Chalmers Mfg. Co., Milwaukee, Wis., Q, $2

**AHS J.** American Helicopter Society, Journal, 2 E. 64 St., New York 21, N.Y., Q, $4

**AHS Newsletter.** American Helicopter Society, Newsletter, 2 E. 64 St., New York, 21 N.Y., M, $3

**Am. Av.** American Aviation, 1001 Vermont Ave., NW, Washington 5, D.C., SM, $5

**Am. Helicopter.** American Helicopter, 32 E. 57 St., New York 22, N.Y., M, $3.50

**American Aviation Daily,** 1001 Vermont Ave., NW, Washington 5, D.C., Daily, $200

**Appl. Hydraulics.** Applied Hydraulics, 1240 Ontario St., Cleveland 13, Ohio, M, $5

**Appl. Mech. Rev.** Applied Mechanics Reviews. Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex., M, $25

**Appl. Sci. Res., Sect. A.** Applied Scientific Research, Section A, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

**Appl. Sci. Res., Sect. B.** Applied Scientific Research, Section B, 9 Lange Voorhout, The Hague, Netherlands, Irreg., 21.50 guilder

**Arch. Budowy Maszyn.** Archiwum Budowy Maszyn. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

**Arch. Mech. Stosowanej.** Archiwum Mechaniki Stosowanej. Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 100 zl.

**Argentina Aérea,** Moreno 360, Buenos Aires, Argentina, M, $3

**ASEA Journal.** ASEA, Västerås, Sweden, M

**Auster News.** Auster Aircraft, Ltd., Rearsby Aerodrome, Leicester, England, Irreg.

**Australian J. Phys.** Australian Journal of Physics. Commonwealth Scientific and Industrial Research Organization, 314 Albert St., East Melbourne C.2., Australia, Q, 30s.

**Auto. Ind.** Automotive Industries, Chestnut & 56 Sts., Phila. 39, Pa., SM, $2

**Av. Age.** Aviation Age, 205 E. 42 St., New York 17, N.Y., M, $10

**Av. Week.** Aviation Week, 330 W. 42 St., New York 36, N.Y., W, $6

**Avia Vliegwereld.** Royal Aero Club of the Netherlands, Anna Paulownaplein 3, The Hague, Netherlands, BW, 11 fl.

**Aviation Week Market Letter,** 330 W. 42 St., New York 36, N.Y., M

**Avión.** Reál Aéro Club de España, Carrera de San Jerónimo 19, Madrid, Spain, M, 250 pesetas

**Battelle Tech. Rev.** Battelle Technical Review. Battelle Memorial Institute, 505 King Ave., Columbus 1, Ohio, M

**Bee Hive,** United Aircraft Corp., East Hartford, Conn., Q

**Bell System Tech. J.** Bell System Technical Journal. American Telephone and Telegraph Co., 195 Broadway, New York 7, N.Y., BM, $3

**BOAC Review.** British Overseas Airways Corp., Stratton House, Piccadilly, London W 1, England, M

**Boeing Mag.** Boeing Magazine. Boeing Airplane Co., 7755 E. Marginal Way, Seattle, Wash., M

**Bristol Quart.** The Bristol Quarterly. Bristol Aeroplane Company, Ltd., Filton House, Bristol, England, Q

**Brit. Aircraft Ind. Bul.** British Aircraft Industry Bulletin. Society of British Aircraft Constructors, 29 King St., St. James, London SW 1, England, Q

**Brit. J. Appl. Phys.** British Journal of Applied Physics. Institute of Physics, 47 Belgrave Sq., London SW 1, England, M, $11.50

**Brit. Welding J.** British Welding Journal. Institute of Welding, 2 Buckingham Gardens, London, SW 1, England, M, £5

**Bul. Acad. Polonaise Sci.** Bulletin de l'Académie Polonaise des Sciences. Polska Academia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 40 zl.

**Bul. AMS.** American Meteorological Society, Bulletin, 3 Joy St., Boston 8, Mass., 10 issues per year, $8

**Bul. Liais. Doc.** Bulletin de Liaison et de Documentation du Secrétariat Général à l'Aviation Civile et Commerciale, 93 blvd. du Montparnasse, Paris 6, France, BM

**Can. Aero. J.** Canadian Aeronautical Journal. Canadian Aeronautical Institute, Commonwealth Building, 77 Metcalfe St., Ottawa, Canada, M, $4

**Can. Airline Pilot.** The Canadian Airline Pilot. The Canadian Airline Pilots Assn., 400 Electric Railway Chambers, Winnipeg, Manitoba, Canada, Q

**Can. J. Phys.** Canadian Journal of Physics. National Research Council, Ottawa 2, Canada, M, $4

**Can. J. Tech.** Canadian Journal of Technology. National Research Council, Ottawa 2, Canada, BM, $3

**Canada, NAE Quart. Bul.** Canada, National Aeronautical Establishment, Quarterly Bulletin, Montreal Road, Ottawa, Canada, Q

**CEC Recordings.** Consolidated Electrodynamics Corp., 300 North Sierra Madre Villa, Pasadena, Calif., BM

**Chartered Mech. Engr.** The Chartered Mechanical Engineer: The Journal of the Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London SW 1, England, 10 issues per year, £2. 5s. 6d.

**Cienc. Aero.** Ciencia Aeronáutica, Apartado de Correos 3879, Caracas, Venezuela, M, $4

**Ciencia y Tecnología.** Pan American Union, Washington 6, D.C., Q

**Data Processing Digest.** Canning, Sisson, & Associates, 914 South Robertson Blvd., Los Angeles 35, Calif., M, $24

**Douglas Serv.** Douglas Service. Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Calif., BM

**Elec. Commun.** Electrical Communication. International Telephone and Telegraph Corp., 67 Broad St., New York 4, N.Y., Q, $2

**Elec. Eng.** Electrical Engineering. American Institute of Electrical Engineers, 33 W. 39 St., New York 18, N.Y., M, $12

**Elec. Mfg.** Electrical Manufacturing, 1250 6th Ave., New York 20, N.Y., M

**Electronic Appl. Rel. Rev.** Electronic Applications Reliability Review. Radio-Electronics-Television Manufacturers Assn., 500 Fifth Ave., New York 36, N.Y., Irreg.

**Electronic Des.** Electronic Design, 19 E. 62 St., New York 21, N.Y., M

**Electronic Eng.** Electronic Engineering, 28 Essex St., Strand, London WC 2, England, M, $4

**Electronics,** 330 W. 42 St., New York 36, N.Y., M, $6

**Energetica si Hidrotehnica,** str. Ioan Ghica 3, Bucarest, Rumania, M, lei 30

**Eng. J.** Engineering Journal. Engineering Institute of Canada, 2050 Mansfield St., Montreal, Canada, M, $6

**The Engr.** The Engineer, 28 Essex St., London WC 2, England, W, £3

**Engr. Dig.** The Engineers' Digest, 120 Wigmore St., London W1, England, M, $7.50

**Ericsson Tech.** Ericsson Technics. Telefonaktiebolaget L.M. Ericsson, Stockholm 32, Sweden, SA

**Esso Air World.** Esso Export Corp., 60 W. 49 St., New York 20, N.Y., BM

**Esso Aviation News Digest.** Esso Export Corp., 45 Rockefeller Plaza, New York 21, N.Y., W

**FAI Bul.** Fédération Aéronautique Internationale, Bulletin, 6, rue Galilée, Paris, France, Q

**FAI Circ. Inf.** Fedération Aéronautique Internationale, Circulaire d'Information, 6, rue Galilée, Paris, France, Irreg.

**Fasteners.** Industrial Fasteners Institute, 1517 Terminal Tower, Cleveland 13, Ohio, Q

**Flight,** Dorset House, Stamford St., London SE 1, England, W, $14

**Flight Control.** Eclipse-Pioneer Div., Bendix Aviation Corp., Teterboro, N.J., M

**Flight Mag.** Flight Magazine, 2700 N. Haskell, Dallas, Tex., M, $3

**Flugwehr und -Technik,** 16 Promenadenstrasse Frauenfeld, Switzerland, M, 13 Sw. fr.

**Flugwelt, Bahnhofstr.** 61, Wiesbaden, Germany, M, DM 21.60

**Flying,** 366 Madison Ave., New York 17, N.Y., M, $4

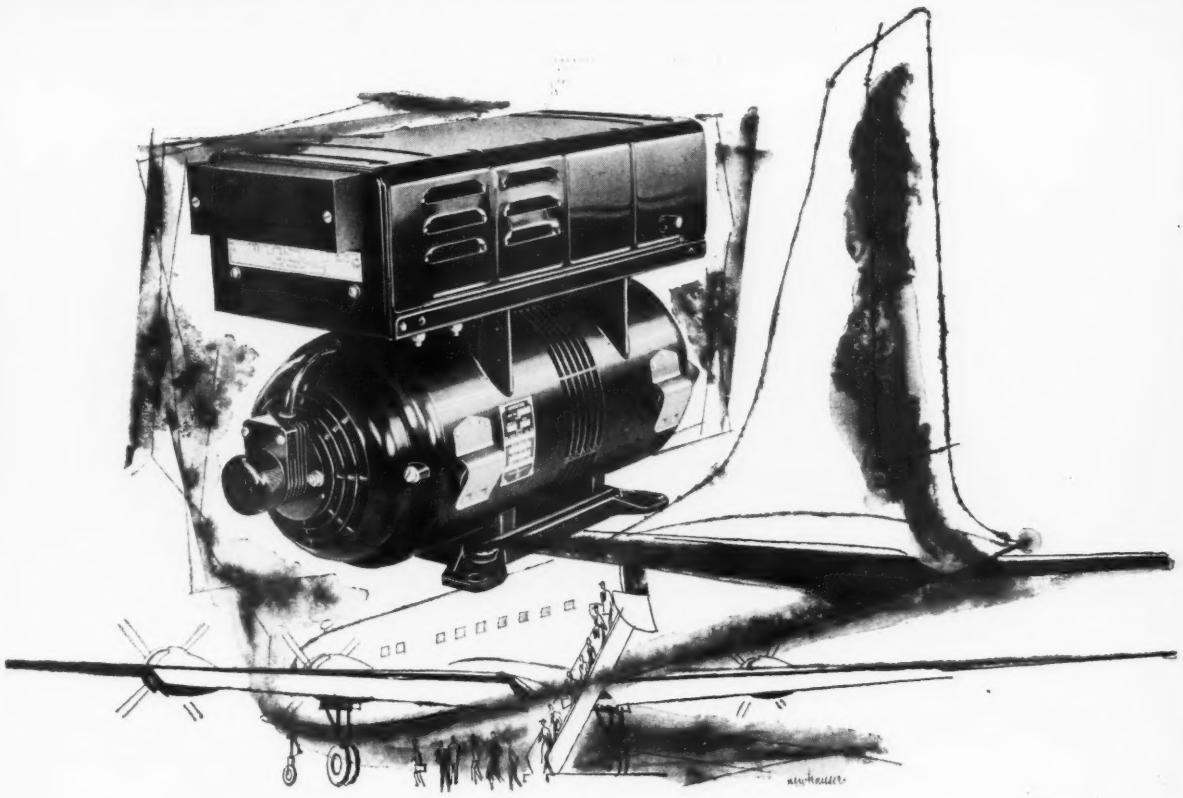
**Flying Safety.** USAF Office of Flying Safety. Superintendent of Documents, Washington 25, D.C., M, $3

**Forschung Gebiete Ing., Ausg. A.** Forschung auf dem Gebiete des Ingenieurwesens, Ausgabe A. Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, BM, DM 51

**The Frontier.** Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., Q

**G-E Rev.** General Electric Review. General Electric Co., Schenectady 5, N.Y., BM

**GM Eng. J.** General Motors Engineering Journal. General Motors Technical Center.



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Send for product data bulletin No. 1344 for detailed information on this important Jack & Heintz first. Write Jack & Heintz, Inc., 17632 Broadway, Cleveland 1, Ohio. Export Department: 13 East 40th Street, New York 16, New York.

**F45-10 INVERTER**
**Operating Characteristics**

| | Single Phase * | Three Phase |
|---|---|---|
| **Output Rating** | | |
| Full Load | 3000 va | 3000 va |
| Rated a-c Voltage | 115 | 115 |
| Line Amps | 24 | 15 |
| Nominal Frequency (cps) | 400 | 400 |
| Power Factor | 90% Lag to 95% Lead | |
| **Rated Input Voltage — d-c** | 27½ | 27½ |
| **Input Amperes — d-c** (at Rated Voltage) | | |
| No Load | 44 | 44 |
| Full Load | 185 | 185 |
| **Over-all Dimensions—Inches** | | |
| Length | 17 13/16 | |
| Width | 7 1/16 | |
| Height | 11 13/16 | |
| **Weight—Pounds** | 54 | |

* Load across terminals BA

**JACK & HEINTZ ELECTRIC AIRCRAFT EQUIPMENT**

P.O. Box 177, North End Station, Detroit 2, Mich., BM

**Greer Topics.** Greer Hydraulics, Inc., New York International Airport, Jamaica 30, N.Y., 3 issues per year

**Guild J.** Guild Journal. The Guild of Air Pilots and Air Navigators of the British Empire, 19 Park Lane, London W 1, England, Q

**Handley-Page Bul.** Handley-Page Bulletin. Handley-Page Ltd., London NW 2, England, Q

**Honeywell Flight Lines.** Aeronautical Division, Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Road, Minneapolis 13, Minn., BM

**Hunting Group Rev.** Hunting Group Review. 4 Dunraven St., Park Lane, London W 1, England, Q

**Hydraulic Engr.** Hydraulic Engineer. Electrol Inc., 85 Grand St., Kingston, N.Y., BM

**IATA Bul.** IATA Bulletin. International Air Transport Assn., International Aviation Bldg., 1080 University St., Montreal 3, Canada, SA, $3.75

**ICAO Bul.** ICAO Bulletin. International Civil Aviation Organization, International Aviation Bldg., 1080 University St., Montreal 3, Canada, M, $2

**IME Proc.** Institution of Mechanical Engineers, Proceedings, 1 Birdcage Walk, Westminster, London SW 1, England, Irreg.

**Ind. Labs.** Industrial Laboratories, 201 N. Wells St., Chicago 6, Ill., M

**Ind. Quality Control.** Industrial Quality Control. American Society for Quality Control, Inc., Room 6197, 161 W. Wisconsin Ave., Milwaukee 3, Wis., M, $9

**Ind. Res. Newsletter.** Industrial Research Newsletter. Armour Research Foundation, Illinois Institute of Technology, Technology Center, Chicago 16, Ill., M

**Ind. Sci. & Eng.** Industrial Science and Engineering, 201 N. Wells St., Chicago 6, Ill., BM

**Ind. South.** Industrial South. Southern Assn. of Science and Industry, 5009 Peachtree Road, North Atlanta 19, Ga., BM, $5

**Indian AF Quart.** Indian Air Force Quarterly. Directorate of Training, Air HQ, New Delhi, India, Q

**Indian Airman,** Roy Mansions, Behala, Calcutta 34, India, M, 10 Rupees

**Indian Skyways,** Gandhigram Road, Juhu, Bombay 23, India, M, 20 Rupees

**Informations Aéronautiques.** Union Syndicale des Industries Aéronautiques, 4 rue Galilée, Paris 16, France, W

**Ing.-Arch.** Ingenieur-Archiv, Neuenheimer Landstr. 24, Heidelberg, Germany, BM

**Inst. Roy. Meteorol. Belg.** Institute Royal Météorologique de Belgique, Bulletin, Uccle, Brabant, Belgium, Irreg.

**Instrumentation.** Industrial Division, Minneapolis-Honeywell Regulator Co., Wayne & Windrim Aves., Philadelphia 44, Pa., BM

**Instruments and Automation,** 1600 N. Main St., Pontiac, Ill., M, $4

**Interavia,** 6 Corraterie, Geneva, Switzerland, M, $7

**Interchem. Rev.** Interchemical Review. Interchemical Corp., 432 W. 45 St., New York 36, N.Y., Q

**IRE Trans.** Institute of Radio Engineers, Transactions, 2 E. 79th St., New York 21, N.Y.
- **ANE.** Aeronautical and Navigational Electronics, Q, $17
- **AP.** Antennas and Propagation, Q, $17
- **CS.** Communications Systems, Q, $17
- **EC.** Electronic Computers, Q, $17

**ISA J.** Instrument Society of America, Journal, 1319 Allegheny Ave., Pittsburgh 33, Pa., M, $4

**J. Air Law & Commerce.** Journal of Air Law & Commerce. Northwestern University, Chicago 11, Ill., Q, $6

**J. Appl. Mech.** Journal of Applied Mechanics. American Society of Mechnical Engineers, 29 W. 39 St., New York 18, N.Y., Q, $5

**J. Appl. Phys.** Journal of Applied Physics. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $12

**J. Astronautics.** Journal of Astronautics. American Astronautical Society, 516 Fifth Ave., New York 36, N.Y., Q, $6

**J. Atmos. & Terrestrial Phys.** Journal of Atmospheric and Terrestrial Physics, 4 Fitzroy Square, London W1, England; 122 E. 55th St., New York 22, N.Y., BM, $14

**J. Av. Med.** Journal of Aviation Medicine. Aero Medical Assn., 2642 University Ave., St. Paul 14, Minn., BM, $7.50

**J. Brit. Interplanetary Soc.** British Interplanetary Society, Journal, 12 Bessborough Gardens, London SW 1, England, BM, 24s.

**J. Franklin Inst.** Franklin Institute, Journal, Parkway at 20 St., Philadelphia 3, Pa., M, $10

**J. Helicopter Assn. Gt. Brit.** Helicopter Assn. of Gt. Britain, Journal, 4, The Sanctuary, Westminster, London SW 1, England, Q

**J. Hokkaidô Gakugei U., Sect. B.** Hokkaidô Gakugei University, Journal, Section B, Sapporo, Japan, Q

**J. Indian Inst. Sci.** Indian Institute of Science, Journal, Bangalore 3, India, M, $6.50

**J. Inst. Navigation.** Institute of Navigation, Journal, 1 Kensington Gore, London SW 7, England, Q, $6

**J. Inst. Transp.** Institute of Transport, Journal, 80 Portland Place, London W 1, England, BM, 21s.

**J. Japan Soc., Aero. Eng.** Japan Society of Aeronautical Engineering, Journal, Hikokwan No. 3, 1-chome, Shiba-Tamura-cho, Minato-ku Tokyo, Japan, M

**J. Math. & Phys.** Journal of Mathematics and Physics. MIT, Cambridge 39, Mass., Q, $6

**J. Mech. & Phys. Solids.** Journal of the Mechanics and Physics of Solids, 4 Fitzroy Square, London W 1, England; 122 E. 55th St., New York 22, N.Y., Q, $12.60

**J. Meteorology.** Journal of Meteorology. American Meteorological Society, 3 Joy St., Boston 8, Mass., BM, $9.50

**J. RAeS.** Royal Aeronautical Society, Journal, 4 Hamilton Place, London W 1, England, M, £7 10s. 6d.

**J. Res.** Journal of Research. U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $4

**J. Sci. & Ind. Res.** Journal of Scientific & Industrial Research. Council of Scientific & Industrial Research, 20 Pusa Road, New Delhi 5, India, 15 Rupees

**J. Sci. Instr.** Journal of Scientific Instruments. Institute of Physics, 47 Belgrave Square, London SW 1, England, M, £5

**J. SLAE.** Society of Licensed Aircraft Engineers, Journal (incorporating The Technical Instructor), 1 High St., Maidenhead, Berkshire, England, M, 30s.

**J. So. African Interplanetary Soc.** South African Interplanetary Society, Journal, P.O. Box 2330, Johannesburg, Union of South Africa, Q, 10s.

**J. Space Flight.** Journal of Space Flight (including the Rocket Newsletter). Chicago Rocket Society, 948 119 St., Whiting, Ind., M, $6

**Japan Sci. Rev. Mech. & Elec. Eng.** The Japan Science Review, Mechanical & Electrical Engineering. Japan Society of Mechanical Engineers (with cooperation of allied engineering societies and associations), Maronouchi Bldg., Chiyoda-Ku, Tokyo, Japan, SA, $2

**Jet Age.** A. V. Roe, Ltd., P.O. Box 430, Toronto, Ontario, Canada, Q

**Jet Propulsion.** American Rocket Society, 500 Fifth Avenue, New York 36, N.Y., M, $12.50

**Joint Services Recognition Journal.** Air Ministry, Richmond Terrace, Whitehall, London SW 1, England, M

**Kyushu U., Rep. Res. Inst. Appl. Mech.** Kyushu University, Research Institute for Applied Mechanics, Reports, Fukuoka, Japan, SA

**Lockheed Field Serv. Dig.** Lockheed Field Service Digest. Lockheed Aircraft Corp., Burbank, Calif., BM

**The Log.** British Air Line Pilots Assn., 95 Mount St., London W 1, England, M

**Luftfahrttechnik.** Verein deutscher Ingenieure, Bongardstr. 3, Düsseldorf, Germany, M, DM 43.50

**Mach. Des.** Machine Design, Cleveland 13, Ohio, BW, $10

**Mag. of Magnesium.** Magazine of Magnesium. Brooks & Perkins, Inc., 1950 Fort St., Detroit 16, Mich., Q

**Mag. of Standards.** Magazine of Standards. American Standards Assn., Inc., 70 E. 45 St., New York 17, N.Y., M, $7

**Marconi Rev.** The Marconi Review. Marconi's Wireless Telegraph Co. Ltd., Chelmsford, England, Q

**Materials & Methods,** 430 Park Ave., New York 22, N.Y., M, $2

**Mech. Eng.** Mechanical Engineering. American Society of Mechanical Engineers, 29 W. 39 St., New York 18, N.Y., M, $7

**Metal Treat.** Metal Treatment and Drop Forging, 17–19 John Adam St., Adelphi, London WC 2, England, M, 30s.

**Meteor. Abs. & Bibliog.** Meteorological Abstracts and Bibliography. American Meteorological Society, 3 Joy St., Boston 8, Mass., M, $8

**Meteorological Mag.** The Meteorological Magazine. Air Ministry Meteorological Office. British Information Services, 30 Rockefeller Plaza, New York 20, N.Y., M, $4

**Meteoros.** Servicio Meteorológico Nacional, Buenos Aires, Argentina, Q, 40 pesos

**Mil. Med.** Military Medicine. Assn. of Military Surgeons, 1726 Eye Street, NW, Washington, D.C., M, $7.50

**Military Aircraft Data Sheets.** Aviation Studies (International) Ltd., 29–31 Cheval Place, Knightsbridge, London SW 7, England, Q, £2

**Mo. Weather Rev.** Monthly Weather Review. U.S. Weather Bureau. Supt. of Documents, Washington 25, D.C., M, $3

**Model Airplane News,** 551 Fifth Ave., New York 17, N.Y., M, $3.50

**Motorola Newsgram.** Motorola Communications and Electronics, Inc., 4501 W. Augusta Blvd., Chicago 51, Ill., BM

**Muirhead Technique.** Muirhead & Co., Ltd., Beckenham, Kent, England, Q

**Nav. Res. Logistics Quart.** Naval Research Logistics Quarterly. Office of Naval Research. Superintendent of Documents, Washington 25, D.C., Q, $1.50

**Naval Av. News.** Naval Aviation News. Chief of Naval Operations and Bureau of Aeronautics. Superintendent of Documents, Washington 25, D.C., M, $2

**New Frontiers.** The Garrett Corp., 9851 Sepulveda Blvd., Los Angeles 45, Calif., SA

**News Eng.** News in Engineering. Engineering Experiment Station, Ohio State University, Columbus 10, Ohio, Q, $1

**News Report,** National Academy of Sciences, National Research Council, 2101 Constitution Ave., Washington 25, D.C., BM, $2

**Noice Control.** Acoustical Society of America, 57 East 55 St., New York 22, N.Y., BM, $8

**Nuclear Eng.** Nuclear Engineering, Bowling Green Lane, London EC 1, England, M, $7

**Official Air Line Guide,** 1001 Vermont Ave., NW, Washington 5, D.C., M, $13.50

**Ordnance.** American Ordnance Assn., 708 Mills Bldg., Washington 6, D.C., BM, $4.50

**Pacific J. Math.** Pacific Journal of Mathematics. Univ. of California Press, Berkeley 4, Calif., Q, $12

**Papers in Meteorology & Geophys.** Papers in Meteorology and Geophysics. Meteorological Research Institute, Mabashi, Suginami, Tokyo, Japan, Irreg.

**Pegasus.** Fairchild Engine and Airplane Corp., Hagerstown, Md., M

**Philips Tech. Rev.** Philips Technical Review. N.V. Philips Co., Eindhoven, Netherlands, M, $5

**Philos. Mag.** The Philosophical Magazine, Red Lion Court, Fleet St., London EC 4, England, M, £8

**Philos. Trans. Royal Soc. (London), Ser. A** Royal Society (London), Philosophical Transactions, Series A, Mathematical and Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg., £9 9s.

**Photographic Eng.** Photographic Engineering. Society of Photographic Engineers, Box 6077, Mid-City Sta., Washington 5, D.C., Q, $8

**Planes.** Aircraft Industries Assn. of America, 610 Shoreham Bldg., Washington 5, D.C., M

**Proc. Cambridge Philos. Soc.** Cambridge Philosophical Society, Proceedings, Free School Lane, Cambridge, England, Q, £5

**Proc. IEE B.** Institution of Electrical Engineers, Proceedings, Part B, Savoy Place, London WC 2, England, BM, £2 5s.

**Proc. Inst. Electronics.** Institution of Electronics, Proceedings, 5 Baron Place, London SE 1, England, Irreg.

**Proc. IRE.** Institute of Radio Engineers, Proceedings, 1 E. 79 St., New York 21, N.Y., M, $18

**Proc. Lond. Math. Soc.** London Mathematical Society, Proceedings, Amen House, London EC 4, England, Q, £4

**Proc. Royal Soc. (London), Ser. A.** Royal Society (London), Proceedings, Series A, Mathematical & Physical Sciences, Burlington House, Piccadilly, London W 1, England, Irreg.

**Prod. Eng.** Product Engineering, 330 W. 42 St., New York 36, N.Y., M, $5

**Propel,** Mariagervej 4, Helsingor, Denmark, M

**Protar,** Solothurn, Switzerland, BM, 15 Sw. fr.

**Quart. Appl. Math.** Quarterly of Applied Mathematics. Brown University, Providence 12, R.I., Q, $6

**Quart. J. Mech. & Appl. Math.** Quarterly Journal of Mechanics and Applied Mathematics, Amen House, London EC 4, England, Q, 60s.

**La Recherche Aéronautique.** Office National d'Etudes et de Recherches Aéronautiques (ONERA), 29 ave. de la Division-Leclerc, Chatillon-sous-Bagneux (Seine), France, BM, 4.300 fr.

**Rec. Ocean. Works Japan.** Records of Oceanographic Works in Japan. Japanese National Commission for UNESCO, 4-3 Kasumigasiki, Chiyoda-ku, Tokyo, Japan, Irreg.

**Res. Trends.** Research Trends. Cornell Aéronautical Laboratory, Inc., 4455 Genessee St., Buffalo 21, N.Y., Q

**Rev. Aérea Latinoamericana.** Revista Aérea Latinoamericana, 247 E. 50 St., New York 22, N.Y., M, $2

**Rev. Aero.** Revista de Aeronáutica. Ministro del Aire, 8 Romero Robledo, Madrid, Spain, M, 90 pesetas

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**Rev. Nac. Aero.** Revista Nacional de Aeronáutica, 741 Ave. Cordoba, Buenos Aires, Argentina, M, $6

**Rev. Sci. Instr.** Review of Scientific Instruments. American Institute of Physics, 57 E. 55 St., New York 22, N.Y., M, $9

**Rev. Transp.** Revista Transporturilor, Str. Ioan Ghica 3, Bucarest, Rumania, M, lei 30

**Revue SNCASO.** Société Nationale de Constructions Aéronautiques du Sud-Ouest, 105 ave. Raymond Poincaré 1, Paris 16, France, Q

**Riv. Aero.** Rivista Aeronautica. Ministero Difesa—Aeronautica, viale dell'Universitá 4, Rome, Italy, M, $7

**Riv. Med. Aero.** Rivista di Medicina Aeronautica, via P. Gobetti 2, Rome, Italy, Q, L. 3,600

**Riv. Meteorologia Aero.** Rivista di Meteorologia Aeronautica. Servizio Meteorologico d'Aeronautica, via San Vincenzo di Paoli 11, Rome, Italy, Q, L. 3,000

**Rozprawy Inzynierskie.** Polska Akademia Nauk, ul. Nowy Swiat 72, Warsaw, Poland, Q, 80 zl.

**Ryan Reporter.** Ryan Aeronautical Co., P.O. Box 311, San Diego 12, Calif.

**Saab Sonics.** Saab Aircraft Co., Linköping, Sweden, Irreg.

**SAE J.** Society of Automotive Engineers, Journal, 29 W. 39 St., New York 18, N.Y., M, $10

**Safety News Letter, Air Transp. Sect.** Safety News Letter, Air Transport Section. National Safety Council, Chicago 11, Illinois, M

**Sailplane and Glider,** 8 Lower Belgrave St., London SW 1, England, BM, 12s. 9d.

**SBAC Press Summary.** Society of British Aircraft Constructors, 29 King St., St. James's, London SW 1, England, W

**Sci. Mo.** The Scientific Monthly. American Assn. for the Advancement of Science, 1515 Mass. Ave., NW, Washington 5, D.C., M, $7.50

**Science.** American Assn. for the Advancement of Science, 1515 Mass. Ave., NW, Washington 5, D.C., W, $7.50

**Shell Av. News.** Shell Aviation News. Aviation Dept., Shell Oil Co., 50 W. 50 St., New York 20, N.Y.,M

**Skyways,** 122 E. 42 St., New York, N.Y., M, $4

**Soaring.** Soaring Society of America and the Soaring Assn. of Canada, P.O. Box 71, Elmira, N.Y.; Ferguson Rd., Dallas 28, Tex., BM, $4

**Solar Blast.** Solar Aircraft Co., San Diego 12, Calif., Q

**SPE J.** Society of Plastic Engineers, Journal, 35 East Putnam Ave., Greenwich, Conn., M, $4

**Sperry Eng. Rev.** Sperry Engineering Review, Sperry Gyroscope Co., Great Neck, N.Y., BM

**Sperry Rev.** The Sperry Review. The Sperry Gyroscope Co., Ltd., Great West Road, Brentford, Middlesex, England, SA

**Sperryscope.** Sperry Rand Corp., 30 Rockefeller Plaza, New York 20, N.Y., Q

**Steel Processing,** 624 Grant Bldg., Pittsburgh 30, Pa., M, $2.50

**Stud. Cerc. Mec. Aplic.** Studii si Cercetari de Mecanica Aplicata. Academia Republicii Populare Romine, Bucarest, Rumania, Q

**Stud. Cerc. Stiint.** Studii si Cercetari Stiintifice. Academia Republicii Populare Romine, Bucarest, Rumania, Q

**Sylvania Technologist.** Sylvania Electric Products, Inc., Bayside, N.Y., Q, $1.50

**Taylor Tech.** Taylor Technology. Taylor Instrument Companies, Rochester 1, N.Y., Q

**Tec. Ital.** Technica Italiana. Consiglio Nazionale delle Ricerche, via Beccaria 6, Trieste, Italy, M, L. 6,000

**Tech. et Sci. Aéronautiques.** Technique et Science Aéronautiques. Assn. Française des Ingénieurs et Techniciens de l'Aéronautique (AFITA), 6 rue Cimarosa, Paris 16, France, BM

**Tech. Lotnicza.** Technika Lotnicza, Nowowiejska 24, Warsaw 10, Poland, BM, 54 zl.

**Tech. News Bul.** Technical News Bulletin, U.S. National Bureau of Standards. Supt. of Documents, Washington 25, D.C., M, $1

**Tech. Rev.** The Technology Review. MIT, Cambridge 39, Mass., M, $4

**Tek. Tidsk.** Teknisk Tidskrift. Svenska Teknologföreningen, Box 841, Stockholm 1, Sweden, W, 50 kr.

**Tele-Tech.** Tele-Tech & Electronic Industries, 480 Lexington Ave., New York 17, N.Y., M, $5

**Thermik,** Obere Maschstrasse 8, Göttingen, Germany, M, DM 10

**Thompson Prod. Eng. Bul.** Thompson Products Engineering Bulletin. Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio, Irreg.

**Tôhoku U. Rep. Inst. High Speed Mech.** Tôhoku University, Institute of High Speed Mechanics, Reports, Sendai, Japan

**Tool Engr.** Tool Engineer. American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich., M, $6

**Trans. ASME.** American Society of Mechanical Engineers, Transactions, 29 W. 39 St., New York 18, N.Y., 8 issues per year, $12

**Trans. Soc. Inst. Tech.** Society of Instrument Technology, Transactions, 4, Grosvenor Gardens, London SW 1, England, Q, £2 10s.

**Trend in Eng.** The Trend in Engineering. Engineering Experiment Station, University of Washington, Seattle 5, Wash., Q

**United Air Lines News.** United Air Lines, Inc., 5959 S. Cicero Ave., Chicago 38, Ill., M

**U.S. Air Serv.** U.S. Air Services, Transportation Bldg., Washington 6, D.C., M, $3

**Vickers Mag.** Vickers, Ltd., Vickers House, London SW 1, England, SA

**De Vliegende Hollander.** Royal Netherlands Air Force, Gevers Deynootplein 5, Scheveningen, Netherlands, M, 5.50 fl.

**W. U. Tech. Rev.** Western Union Technical Review. Western Union Telegraph Co., 60 Hudson St., New York 13, N.Y., Q, $1.50

**Welding J.** Welding Journal. American Welding Society, 33 W. 39 St., New York 18, N.Y., M, $7

**Weltraumfahrt,** Stuttgarterstr. 20, Frankfurt a.M., Germany, Q, DM 9.84

**Westinghouse Engr.** Westinghouse Engineer Westinghouse Electric Corp., P.O. Box 2278, 3 Gateway Center, Pittsburgh 30, Pa., BM, $2.50

**Whites Av.** Whites Aviation, Dilworth Bldg., Queen St., Auckland, New Zealand, M, $3

**Wings.** Royal New Zealand Aero Club, Inc., 1 Marion St., Wellington, N.Z., M, 15s.

**Wireless Engr.** Wireless Engineer, Dorset House, Stamford St., London SE 1, England, M, $7.50

**Wireless World,** Dorset House, Stamford St., London SE 1, England, M, $5

**WMO Bul.** WMO Bulletin. World Meteorological Organization, Campagne Rigot, ave. de la Paix, Geneva, Switzerland, Q, 4 Sw. fr.

**ZAMM.** Zeitschrift für angewandte Mathematik und Mechanik, Mohrenstr. 39, Berlin W8, Germany, M, DM 60

**ZAMP.** Zeitschrift für angewandte Mathematik und Physik, Basel 10, Switzerland, BM, 48 Sw. fr.

**ZFW.** Zeitschrift für Flugwissenschaften. Wissenschaftliche Gesellschaft für Luftfahrt e.V. (WGL), Burgplatz 1, Braunschweig, Germany, M, DM 48

## Reports

**A&M Coll. Tex. Eng. Exp. Sta. Res. Rep.** Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Research Report

**ADA Info. Bul.; Res. Rep.** The Aluminium Development Association, Information Bulletin; Research Reports (London)

**Aero. Inst. Tech. Hochschule, Braunschweig.** Bericht. Aerodynamisches Institut der Technischen Hochschule, Braunschweig, Bericht

**Aerojet-Gen. TN.** Aerojet-General Corporation, Technical Notes

**Argonne Natl. Lab. Rep.** Argonne National Laboratory, Reports

**ASME Preprints; Papers.** American Society of Mechanical Engineers, Preprints; Papers

**Australia, Aero. Res. Comm. Rep.** Australia, Aeronautical Research Committee, Reports

**Australia, Aero. Res. Consultative Comm. Rep.** Australia, Department of Supply, Aeronautical Research Consultative Committee, Reports

**Australia, ARL ATM; EN; IN; Mech. Eng. TM; Notes; Rep.; S&M Monogr.; S&M TM.** Australia, Department of Supply, Aeronautical Research Laboratories, Aerodynamics Technical Memorandum; Engines Notes; Instruments Notes; Mechanical Engineering Technical Memorandum; Notes; Reports; Structures and Materials Monographs; Structures and Materials Technical Memorandum

**Australia, CSIR Aero. Res. Rep.** Australia, Council for Scientific and Industrial Research, Aeronautical Research Reports

**Australia, CSIRO Radiophys. Lab. Rep.** Australia, Commonwealth Scientific and Industrial Research Organization, Radiophysics Laboratory, Reports

**AVRO Rep.** A. V. ROE Canada Ltd. Technical Department, Reports

**Braunschweig Tech. Hochschule Inst. Strömungsmech. Rep.** Braunschweig Technische Hochschule, Institut für Strömungsmechanik, Reports

**Bristol Aircraft, Wind-Tunnel Dept. Rep.** Bristol Aircraft, Wind-Tunnel Department, Reports

**Brown U. Div. Eng., USAF TR.** Brown University, Division of Engineering, United States Air Force, Technical Reports

**Canada, CARDE Misc. Rep.** Canada, Canadian Armament Research and Development Establishment, Miscellaneous Reports

**Canada, Dept. Mines & Tech. Surveys Rep.** Canada, Department of Mines and Technical Surveys, Reports

**Canada, DRML Rep.** Canada, Defence Research Medical Laboratories, Reports

**Canada, NAE HSAL Rep.** Canada, National Aeronautical Establishment, High Speed Aerodynamics Laboratory, Reports

**Canada, NAE LR; Note; Rep.** Canada, National Aeronautical Establishment, Laboratory Report; Note; Reports

**Canada, NRC Div. Mech. Eng. Rep.** Canada, National Research Council, Division of Mechanical Engineering, Reports

**Canada, RCAF Rockcliffe, Rep.** Canada, Royal Canadian Air Force, Rockcliffe, Reports

**Carnegie Inst. Tech. TR.** Carnegie Institute of Technology, Technical Reports

**Cen. Sviluppo Transp. Aerei.** Centro per lo Sviluppo dei Transporti Aerei (Rome)

**Chrysler Eng. Div. Rep.** Chrysler Corporation, Engineering Division, Reports

**CIT Hydrodynamics Lab. Rep.** California Institute of Technology, Hydrodynamics Laboratory, Reports

**CIT Jet Propulsion Lab. Prog. Rep.** California Institute of Technology, Jet Propulsion Laboratory, Progress Reports

**CIT Mech. Eng. Lab. Rep.** California Institute of Technology, Mechanical Engineering Laboratory, Reports

**CIT Paper; Rep.** California Institute of Technology, Papers; Reports

**CIT So. Calif. CWT Rep.** California Institute of Technology, Southern California Cooperative Wind Tunnel Reports

**Coll. of Aeronautics, Cranfield, Note; Rep.** College of Aeronautics, Cranfield, England, Notes; Reports

**Columbia U. Inst. Air Flight Struc. AF TN.** Columbia University, Institute of Air Flight Structures, Air Force Technical Notes

**Commun. on Pure & Appl. Math.** Communications on Pure and Applied Mathematics

**Cornell Aero. Lab. FRM; Rep.; Transl.** Cornell Aeronautical Laboratory, Inc., Flight Research Memorandum; Reports; Translations

**Douglas Rep.** Douglas Aircraft Company, Inc., Reports

**DVL e.V., Flugtech. Fachgruppen Arbeitsgem., Ing. Ausbuild. Abteil., Mitteil.; Tech. Berichte.** Deutsche Versuchsanstalt für Luftfahrt, Flugtechnische Fachgruppen und Arbeitsgemeinschaften, Ingenieur Ausbildung Abteilung (Berlin-Adlershof), Mitteilungen; Technische Berichte

**Electronics Corp. Amer. TN.** Electronics Corporation of America, Technical Notes

**ETH Inst. für Aerodynamik Mitteilungen.** Eidgenössische Technische Hochschule, Institut für Aerodynamik (Zurich), Mitteilungen

**FIAT Dept. Flight Testing, Paper.** FIAT, Department of Flight Testing, Papers (Italy)

**Flight Safety Fn. Mech. Bul.; Papers.** Flight Safety Foundation, Inc., Mechanics Bulletin; Papers

**France, Min. de l'Air BST; NT; PST.** France, Ministère de l'Air, Bulletin des Services Techniques; Notes Techniques; Publications Scientifiques et Techniques

**France, ONERA Pubs.** France, Office National d'Études et de Recherches Aéronautiques, Publications

**Franklin Inst. Labs. TR.** Franklin Institute Laboratories for Research and Development, Technical Reports

**GALCIT Memo.; TR.** Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, Calif., Memorandums; Technical Reports

**Garbell Res. Foundation, Aero. Ser.** Garbell Research Foundation, Aeronautical Series

**Gt. Brit., AAEE Rep.** Great Britain, Aeroplane and Armament Experimental Establishment, Boscombe Down, Reports

**Gt. Brit., AERE Rep.** Great Britain, Atomic Energy Research Establishment, Reports

**Gt. Brit., ARC CP.** Great Britain, Aeronautical Research Council, Current Papers

**Gt. Brit., ARC R&M.** Great Britain, Aeronautical Research Council, Reports & Memorandums

**Gt. Brit., DSIR FPR Bul.** Great Britain, Department of Scientific & Industrial Research, Forest Products Research Bulletin

**Gt. Brit., MAEE Rep.** Great Britain, Marine Aircraft Experimental Establishment, Reports

**Gt. Brit., Meteorological Off. Prof. Notes & Reps.** Great Britain, Meteorological Office, Professional Notes and Reports

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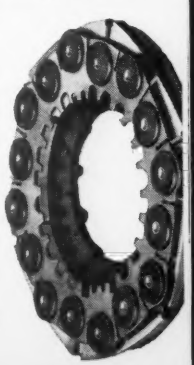

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**Gt. Brit., MOS CDEE P. Transl.** Great Britain, Ministry of Supply, Chemical Defense Experimental Establishment, Porton Translations

**Gt. Brit., MOS GDC TIB Rep. & Transl.** Great Britain, Ministry of Supply, Government Defense Council, Technical Information Bureau, Reports and Translations

**Gt. Brit., MOS TIB S&T Memo.** Great Britain, Ministry of Supply, Technical Information Bureau, Scientific and Technical Memorandums

**Gt. Brit., NGTE Rep.** Great Britain, National Gas Turbine Establishment, Reports

**Gt. Brit., NPL Aerodynamics Div. Rep.** Great Britain, National Physical Laboratory, Aerodynamics Division, Reports

**Gt. Brit. RAE FPRC Rep.** Great Britain, Royal Aircraft Establishment, Flying Personnel Research Committee, Reports

**Gt. Brit., RAE Rep.** Great Britain, Royal Aircraft Establishment, Reports

**Gt. Brit. RAE RPD Rep.** Great Britain, Royal Aircraft Establishment, Rocket Propulsion Department, Reports

**Gt. Brit., RAE TN Aero.; TN Struc.** Great Britain, Royal Aircraft Establishment, Technical Notes (Aeronautical; Structures)

**Harvard U. BHMO MR Studies; Rep.** Harvard University, Blue Hill Meteorological Observatory, Meteorological Radar Studies; Reports

**IAS Preprints; Papers.** Institute of the Aeronautical Sciences, Inc., Preprints; Papers

**Inst. Méc. Fluides, Lille.** Institut de Mécanique des Fluides de Lille (France)

**Iowa Eng. Exp. Sta. Eng. Rep.** Iowa Engineering Experiment Station, Iowa State College, Ames, Iowa, Engineering Report

**Ireland, Meteorological Serv., Geophys. Pubs.** Ireland, Meteorological Service, Geophysical Publications

**La. State U. Eng. Exp. Sta. Bul.** Louisiana State University, Engineering Experiment Station, Bulletin

**Lockheed Aircraft Rep.** Lockheed Aircraft Corporation, Reports

**Max-Planck-Inst. für Strömungsforschung, Mitteil.** Max-Planck-Institut für Strömungsforschung, Mitteilungen (Göttingen)

**Miss. State U. Eng. Res. Sta. Res. Rep.** Mississippi State University, Engineering Research Station, Research Reports

**MIT Hydrodynamics Lab. TR.** Massachusetts Institute of Technology, Hydrodynamics Laboratory, Technical Reports

**MIT ASRL TR.** Massachusetts Institute of Technology, Aeroelastic and Structures Research Laboratory, Technical Reports

**N.C. State Coll. Eng. Sch. Bul.** North Carolina State College, Engineering School Bulletin

**N.C. State Coll. Inst. Statistics, Rep.** North Carolina State College, Institute of Statistics, Reports

**Netherlands, Math. Centrum, Rep.** Netherlands, Mathematisch Centrum (Amsterdam), Reports

**Netherlands, NLL Rep. (Rep. & Trans.)** Netherlands, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), Amsterdam, Reports (Reports and Transactions)

**NFPA Bul.; Papers; Rep.** National Fire Protection Association, Bulletins; Papers; Reports

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**North Amer. Av. Spec. Res. Rep.** North American Aviation Corporation, Special Research Reports

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**O. State U. Eng. Exp. Sta. News.** The Ohio State University, Engineering Experiment Station, News

**Ore. State Coll. Eng. Exp. Sta. Bul.** Oregon State College, Engineering Experiment Station, Bulletin

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**Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech.** Polytechnic Institute of Brooklyn, Department of Aeronautical Engineering and Applied Mechanics

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**RAND Corp. Transl.** The RAND Corporation, Translations

**Rensselaer Polytech. Inst. Dept. Aero. Eng. TR.** Rensselaer Polytechnic Institute, Department of Aeronautical Engineering, Technical Reports

**Res. Trends (Cornell Aero. Lab.).** Research Trends (Cornell Aeronautical Laboratory, Inc.)

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**Stockholm, KTH AERO TN.** Stockholm, Kungliga Tekniska Högskolan, Institutionen för Flygteknik, Technical Notes

**Stockholm, KTH IBS Medd.** Stockholm, Kungliga Tekniska Högskolan, Institutionen för Byggnadsstatik, Meddelanden

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**U. Ark. Engr. Exp. Sta. Bul.** University of Arkansas, Engineering Experiment Station, Bulletin

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**U. Nac. Eva Peron, Fac. Ciencias Fisicomát., Pubs.** Universidad Nacional Eva Peron, Publicaciones de la Facultad de Ciencias Fisicomatemáticas

**U. Tenn. Dept. Civ. Eng. Rep.** University of Tennessee, Department of Civil Engineering, Reports

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**U.S. AEC Rep.** United States Atomic Energy Commission, Reports

**U.S. Army Bal. Res. Lab. Rep.** United States Army Ballistic Research Laboratories, Reports

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**U.S., CAA TDR.** United States, Civil Aeronautics Administration, Technical Development Reports

**U.S., Forest Prod. Lab. Rep.** United States, Forest Products Laboratory, Madison, Wis., Reports

**U.S., NACA Rep.; RM; TM; TN.** United States, National Advisory Committee for Aeronautics, Report; Research Memorandum; Technical Memorandum; Technical Notes

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**U.S., NAES Rep.** United States, Naval Air Experiment Station, Reports

**U.S., Nav. Sch. Av. Med., Pensacola, Fla., Project Rep.** United States, Naval School of Aviation Medicine, Naval Air Station, Florida, Project Reports

**U.S., NavBuAer RDR.** United States, Navy Department, Bureau of Aeronautics, Research Division Reports

**U.S., NAVORD Rep.** United States, Naval Ordnance Reports

**U.S., Navy Dept., David W. Taylor Model Basin, Rep.; Transl.** United States, Navy Department, David W. Taylor Model Basin, Reports; Translations

**U.S., NBS Appl. Math. Ser.** United States, National Bureau of Standards, Applied Mathematics Series

**U.S., NBS Rep.** United States, National Bureau of Standards, Reports

**U.S., NBS Sum. TR.** United States, National Bureau of Standards, Summary Technical Reports

**U.S., NRL Rep.** United States, Naval Research Laboratory, Reports

**U.S., ONR Res. Rep.** United States, Office of Naval Research, Research Report (monthly)

**U.S., ONR Special Devices Cen. TR.** United States, Office of Naval Research, Special Devices Center, Technical Reports

**USAF AEDC TN.** United States Air Force, Arnold Engineering Development Center, Technical Notes

**USAF AMC Eng. Div. Aero. Med. Lab. TR.** United States Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Technical Reports

**USAF APG Rep.** United States Air Force, Air Proving Ground, Reports

**USAF Arctic Aeromed. Lab. Project Rep.** United States Air Force, Arctic Aeromedical Laboratory, Alaska, Project Reports

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**USAF MTC TN.** United States Air Force, Missile Test Center, Technical Notes

**USAF OSR TN.** United States Air Force, Office of Scientific Research, Air Research and Development Command, Technical Notes

**USAF PTRC TN.** United States Air Force, Personnel & Training Research Center, Technical Notes

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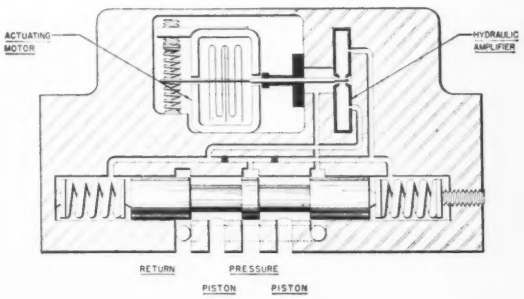


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## Acoustics, Sound, & Noise

**Aircraft Noise as it Relates to the Airport Neighbor.** Charles E. Rosendahl. (*IAS 24th Annual Meeting, New York, Jan. 23–26, 1956, Luncheon Address.*) *Aero. Eng. Rev.*, June, 1956, pp. 71, 72. Description of the NATCC program in terms of such noise originating sources as low-level, high-powered circling operations; accelerated climbing; and high-pitched compressor whine.

**On the Transmission Through a Fuselage Wall of Boundary Layer Noise.** Appendix I—**The Random Radiation of a Plane Surface: Four Limiting Cases.** Appendix II—**The Simplification of the Plate Response Integral.** Appendix III—**The Evaluation of the Integral Scale.** Appendix IV—**Lengths and Time Scales for Thick Boundary Layers.** G. M. Corcos and H. W. Liepmann. *Douglas Rep. SM-19570*, Dec., 1955. 51 pp.

**Boundary-Layer-Induced Noise in the Interior of Aircraft.** H. S. Ribner. (*UTIA Rep. 37*) *CAI Annual Gen. Meeting, Montreal, May 3, 4, 1956*, Preprint. 32 pp. 17 refs. Calculation of the acoustic effects of the running ripples for an infinite sheet, indicating that supersonically moving ripples radiate strong sound in the form of Mach waves and that subsonically moving ripples radiate no sound. Formulas are derived for the mean square surface pressure and the energy flux obtained for an assumed idealized turbulent pressure spectrum.

**Preliminary Flight Survey of Aerodynamic Noise on an Airplane Wing.** Harold R. Mull and Joseph S. Algranti. *U.S., NACA RM E55K07*, Mar. 2, 1956. 8 pp.

**New Type of Tip Jet to Reduce Noise.** E. J. Richards. *J. Helicopter Assn. Gt. Brit.*, Jan., 1956, pp. 404–413. Development of new methods for the design of pressure and exhaust jets that enable a reduction of noise in the most advantageous part of the frequency range.

**The Use of Vibration and Shock Control in Reducing Noise Levels.** Donald H. Vance. *Noise Control*, Mar., 1956, pp. 64–72.

**An Evaluation Technique for Impact-Type Noises.** H. C. Hardy, F. G. Tyzzer, and H. H. Hall. *Noise Control*, Mar., 1956, pp. 38–41, 98. Includes description of an instrument based on the masking principle and designed to provide approximate comparisons between the impact noise and a particular sound field.

**Structure Asymptotique des Ondes Progressives Comportant des Fronts Raides.** J. Brillouin. *France, ONERA NT 30*, 1956. 44 pp. In French. Study of the structures of waves propagating in still, homogenous, and isotropic media at a distance from their source or a caustic point, having a moderate amplitude, and governed by the laws of propagation. Derivation of fundamental equations for the relations governing adiabatic waves, including the dynamic and continuity equations, the equation of state, and the equation of conservation of energy.

**Typical Factory and Office Noise Problems in an Aircraft Plant.** D. R. McAuliffe. *Noise Control*, Mar., 1956, pp. 22–25.

## Aerodynamics

**Dimensionslose Grössen in Grenzgebieten der Aerodynamik.** Theodore von Kármán. *ZFW*, Jan.-Feb., 1956, pp. 3–5. In German. Listing of characteristic parameters occurring in specific domains of the science of aerodynamics, with special emphasis on the nondimensional parameters of aerothermochemistry.

**Neuere Ergebnisse zur Profiltheorie.** Fritz W. Riegels. *ZFW*, Jan.-Feb., 1956, pp. 57–63. 10 refs. In German. Summary of investigations of applied theoretical aerodynamics including first and second fundamental problems of airfoil theory, improvement of the method of calculating laminar and turbulent boundary layers, program controlled computing machines, and the presentation of a two-parametric law of similarity for subsonic and supersonic flow.

### *Aerothermodynamics*

**Laminar Heat Transfer Over Blunt-Nosed Bodies at Hypersonic Flight Speeds.** Lester Lees. *Jet Propulsion*, Apr., 1956, pp. 259–269, 274. 26 refs. Analysis of laminar heat transfer, taking into account the following limiting cases: thermodynamic equilibrium, in which the chemical reaction rates are regarded as "very fast" compared to rates of diffusion across streamlines; and diffusion, as rate-governing, in which the volume recombination rates within the boundary layer are "very slow" compared to diffusion across streamlines.

**Extreme Geschwindigkeiten und thermische Zustände beim Überschallflug.** Klaus Oswatitsch. *ZFW*, Mar.-Apr., 1956, pp. 95–108. In German. Summary of problems related to high-speed flow, including the change of high kinetic energy into extreme thermodynamic states with temperatures of several thousand degrees Kelvin.

**Correlation of Supersonic Convective Heat-Transfer Coefficients from Measurements of the Skin Temperature of a Parabolic Body of Revolution (NACA RM 10).** Leo T. Chauvin and Carlos A. deMoraes. *U.S., NACA TN 3623*, Mar., 1956. 38 pp. 14 refs.

**Effect of Chemical Reactions in the Boundary Layer on Convective Heat Transfer.** David Altman and Henry Wise. *Jet Propulsion*, Apr., 1956, pp. 256–258, 269. Army-sponsored analysis of the relative change in heat-transfer rate resulting from chemical reactions in the boundary layer for either turbulent or laminar flow.

**Free-Flight Measurements of Skin Friction of Turbulent Boundary Layers with High Rates of Heat Transfer at High Supersonic Speeds.** Simon C. Sommer and Barbara J. Short. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Preprint 518*). *J. Aero. Sci.*, June, 1956, pp. 536–542. 17 refs.

**On Laminar Boundary Layers with Heat Transfer.** Wallace D. Hayes. *Jet Propulsion*, Apr., 1956, pp. 270–274.

### *Boundary Layer*

**Energy Dissipation in Turbulent Boundary Layers.** Itiro Tani. *J. Aero. Sci.*, June, 1956, pp. 606, 607. Description of a new method of calculation using a similarity assumption and a single-parameter representation of velocity profiles of the form of velocity-defect law.

**Boundary-Layer Growth and Shock Attenuation in a Shock Tube with Roughness.** Paul W. Huber and Donald R. McFarland. *U.S., NACA TN 3627*, Mar., 1956. 49 pp. 15 refs. Investigation of unsteady-flow turbulent boundary-layer characteristics for artificially thickened boundary layers using an optical technique involving the bow-wave shape of bullets fired in a shock tube. Includes a comparison with the Schlichting flat-plate steady-flow sand-roughness theory and with steady-flow measurements for sand roughness and for lateral square-bar roughness.

**Exploratory Investigation of Boundary-Layer Transition on a Hollow Cylinder at a Mach Number of 6.9.** Appendix A—**Theoretical Boundary-Layer Profiles.** Appendix B—**Probe Effects.** Mitchel H. Bertram. *U.S., NACA 3546*, May, 1956. 38 pp. 34 refs. Impact pressure surveys to determine the type of boundary layer and an attempt to correlate the available data on cylinders and flat plates by the use of nondimensional parameters involving the pressure and the leading-edge thickness.

**Nouvelle Méthode Approchée de Calcul des Couches Limites Laminaire et Turbulente en Écoulement Compressible.** Alfred Walz. *France, Min. de l'Air PST 309*, 1956. 87 pp. 22 refs. In French. Development of a new approximate method for the calculation of laminar and turbulent boundary layers in compressible flow.

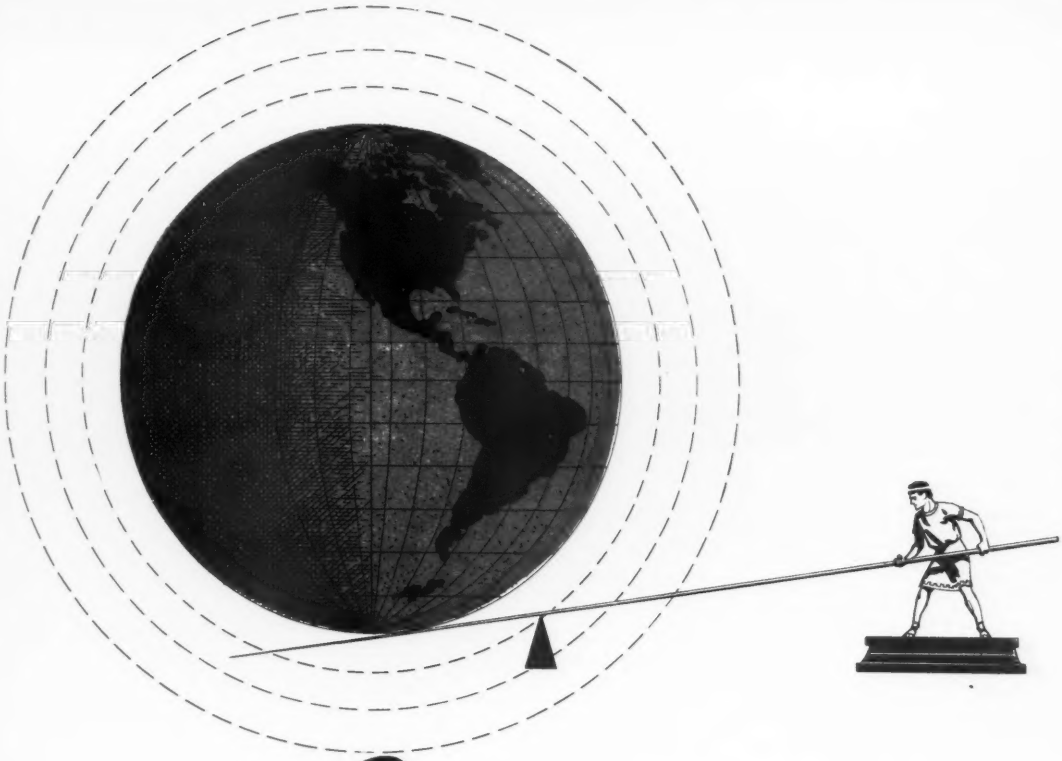
**The Laminar Boundary-Layer with Distributed Suction on an Infinite Yawed Cylinder.** K. D. P. Sinha. *Gt. Brit., ARC CP 214* (Nov. 11, 1954), 1956, 54 pp. 15 refs. BIS, New York. $1.00. Analysis of the spanwise boundary-layer flow with suction distribution, using the case when $U = cx^m$ (when $x$ is the coordinate in the chordwise direction) to find the chordwise velocity distribution at the edge of the boundary layer, and further extended by using the Hartree transformations, to obtain the spanwise velocity distribution.

**Investigation of Boundary-Layer Transition on 10° Cone in Langley 4- by 4-Foot Supersonic Pressure Tunnel at Mach Numbers of 1.41, 1.61, and 2.01.** Archibald R. Sinclair and K. R. Czarnecki. *U.S., NACA 3648*, May, 1956. 17 pp.

**The Effect of Small Laminar Separation Bubble on the Potential Flow Past an Aerofoil.** D. G. Hurley. *Australia ARL AN 148*, Oct., 1955. 21 pp. Development of a method of calculating the effect of a small bump of arbitrary shape, located on the surface of an airfoil, on the surface pressure in its vicinity and of a method of solving the problem of finding the shape of the bump when the changes in pressure produced by the bump are known.

**Boundary-Layer Effect on Local Mach Number Measurements on a Circular Arc Half Profile.** James B. Carroll and Gordon F. Anderson. *J. Aero. Sci.*, June, 1956, pp. 604, 605.

**Zeitliche Auflösung einer ebenen Trennungsfläche der Geschwindigkeit und Dichte.** W. Szablewski. *ZAMM*, Dec., 1955, pp. 465–468. In German. Investi-



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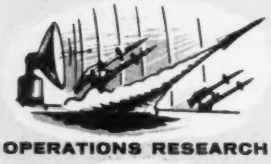
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**Der Einfluss eines Stolperdrahtes auf den Umschlag der Grenzschicht an einer ebenen Platte.** Josef Stüper. *ZFW*, Jan.-Feb., 1956, pp. 30–34. 16 refs. In German. Experimental investigation of the effect of excrescences, consisting of piano wires, on the transition of the boundary layer over a glass plate of 1.68 m. length. Includes a brief discussion of experiments on a research glider with a 32 per cent thick laminar airfoil section of the Griffith type, an approximate reproduction of the pressure distribution over the suction side of the airfoil section at zero angle of incidence by corresponding arrangements inside the closed wind tunnel, and a comparison with measurements over a flat plate without pressure gradient.

**Recent Investigations of the Problem of Transition.** Hugh L. Dryden. *ZFW*, Mar.-Apr., 1956, pp. 89–95. 20 refs. Comprehensive summary of studies of the problem of transition from laminar to turbulent flow, with special emphasis on the generation of turbulence in an incompressible medium and on the stabilizing effect of cooling on the compressible boundary layer.

**Some Aspects of Three-Dimensional Boundary Layer Flows.** R. Sedney. *U.S. Army Bal. Res. Lab., Aberdeen, Rep. 962*, Sept., 1955. 26 pp. 13 refs. Analysis in a normal coordinate system of laminar boundary-layer flow equations using the concept of subtensors to determine the invariance properties. Includes conditions for the Cartesian form of the equations and a criterion for nonsecondary flow in terms of the geodesics of the body surface, with a discussion of the displacement effect of the boundary layer.

**Stabilitätsmindernde Einflüsse bei Absaugegrenzschichten.** Walter Wuest. *ZFW*, Jan.-Feb., 1956, pp. 81–84. 11 refs. In German. Analysis of the difference in theoretically predicted and experimental values for the considerable increase of stability limits of boundary layers by means of suction. Surface waviness, surface roughness, and the nonuniform structure of the suction are some possible causes.

**Ein Verfahren zur Berechnung der laminaren Grenzschicht mit beliebiger Druckverteilung und Wärmeübergang für alle Machzahlen.** Kurt Werner Mangler. *ZFW*, Jan.-Feb., 1956, pp. 63–66. 10 refs. In German. Development of a numerical iterative method for the calculation of the laminar boundary layer for an arbitrary pressure and temperature distribution along the wall for any Mach Number, taking into account the dependency of the viscosity and the Prandtl Number on the temperature.

**Wandnahe Geschwindigkeitsverteilung turbulenter Grenzschichtströmungen mit Druckanstieg.** W. Szablewski. *Ing.-Arch.*, No. 4, 1955, pp. 295–306. In German. Study of the velocity distribution near the wall for turbulent boundary-layer flows with pressure gradient. Includes a comparison with the results of Nikuradse measurements of flow in a divergent channel.

**Perforated Sheets as a Porous Material for Distributed Suction and Injection.**

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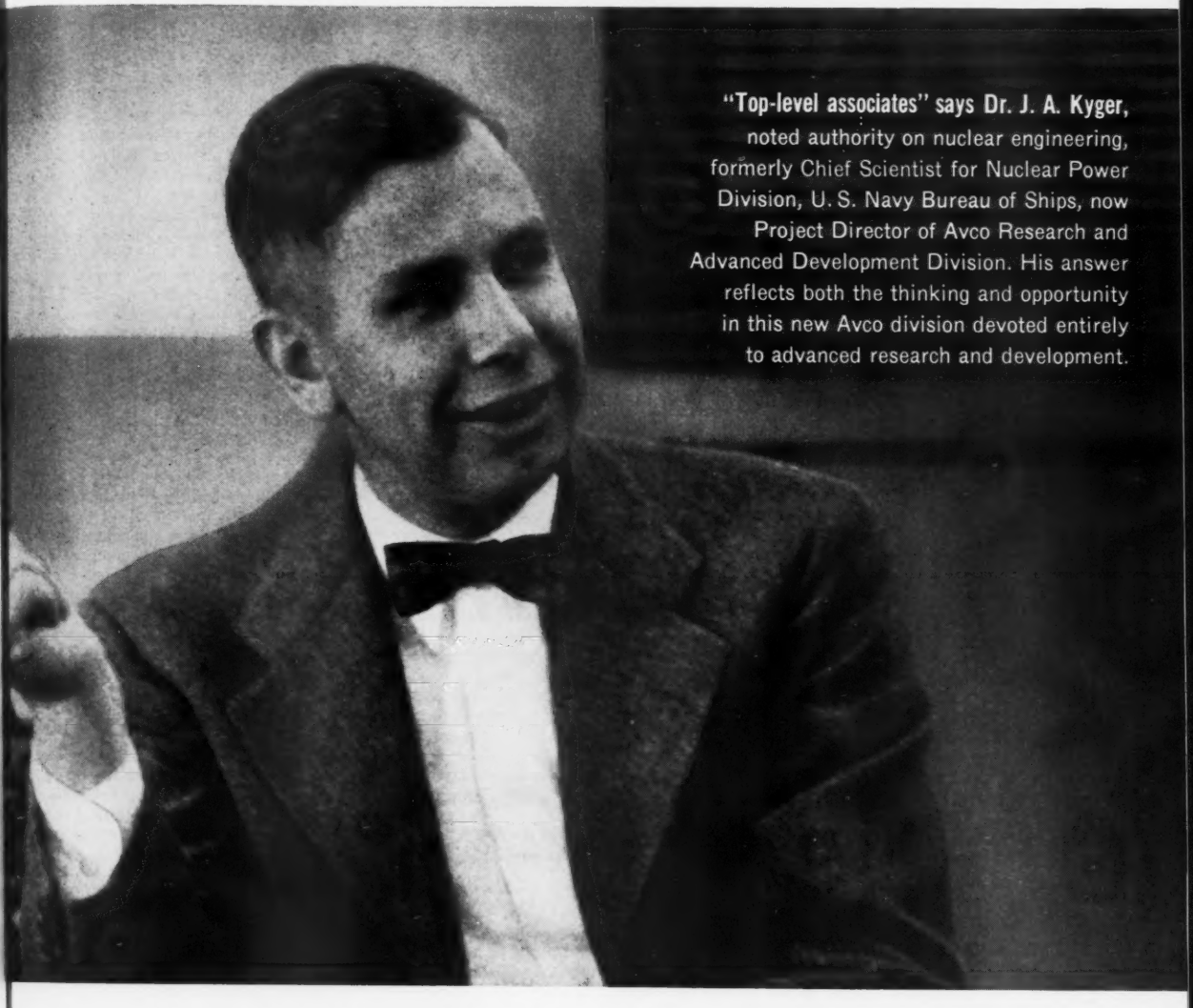

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Robert E. Dannenberg, Bruno J. Gambucci, and James A. Weiberg. *U.S., NACA TN 3669*, Apr., 1956. 27 pp. 12 refs. Measurements of the resistance to airflow of a series of perforated metal sheets having open areas ranging from less than 1 per cent up to 41 per cent.

**A Wind-Tunnel Investigation of a 0.4-Scale Model of an Assault-Transport Airplane with Boundary-Layer Control Applied.** Marvin P. Fink, Bennie W. Cocke, and Stanley Lipson. *U.S., NACA RM L55G26a*, May 7, 1956. 63 pp. Tests to evaluate lift, drag, and lateral and longitudinal stability and control characteristics to aid in the design of a flight installation.

### *Control Surfaces*

**The Geared Elevator Tab and Tail-Unit Stiffness Requirements. Appendix I—Effect of Modal Assumptions.** Ll. T. Niblett. *Gt. Brit., ARC R&M 2848* (Apr., 1951), 1955. 18 pp. BIS, New York. $1.25. Formulation of a criterion for the torsional stiffness of tabs through theoretical investigation of the distortions of a hypothetical, semirigid tail unit under the loads induced during the elevator displacement, with calculations for tabs covering one-third, two-thirds, and the whole elevator span, and for various proportions of tabs and forward aerodynamic balance, obtained by the substitution of the aerodynamic coefficients and modal functions in the derived equations.

**Theoretical Analysis of Linked Leading-Edge and Trailing-Edge Flap-Type Controls at Supersonic Speeds. Appendix A—Details of the Linearized Theory Calculations. Appendix B—Correction for Finite Thickness.** E. Carson Yates, Jr. *U.S., NACA TN 3617*, Mar., 1956. 40 pp. 11 refs.

**Theory and Application of the Jet Flap.** R. A. Cole. *Aero. Dig.*, Apr., 1956, pp. 21–27. Discussion of jet lift, losses in the jet, aspect ratio effects, control stability, and safety aspects.

### *Fluid Mechanics & Aerodynamic Theory*

**Nouvelle Interprétation des Phénomènes Fluidodynamiques.** Livio Meloni. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 357–362. In French. Development of a new concept of phenomena of fluid dynamics.

**Einige Integraltransformationen zwischen ebenen und drehsymmetrischen Strömungen.** Hermann Behrbohm. *ZFW*, Jan.-Feb., 1956, pp. 40–44. In German. Derivation of a classical relationship between plane and axial flow presented in a new integral form operating with cylindrical sources along the axis instead of spherical sources.

**The Variational Method in Hydrodynamics.** P. E. Lush and T. M. Cherry. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 6–21. Determination of the steady irrotational isentropic motion of a compressible fluid through a region when the normal mass flow is prescribed over the boundary, with approximate solutions obtained by the Rayleigh-Ritz direct numerical procedure, and with numerical results for streaming past a circular cylinder, which are compared with those obtained by other methods.

**The Slow Steady Motion of Liquid Past a Semi-Elliptical Boss.** G. Power and L. Scott-Hutton. *Pacific J. Math.*, Suppl. II, 1955, pp. 953–962. Application of equations governing the slow steady flow of a viscous incompressible fluid to the solution of the tension of a semi-infinite plane whose edge is indented and traction free.

**Sur le Problème de la Plaque Plane Semi-Infinie en Écoulement Visqueux.** Roger Bader and Jacqueline Gilles. *La Recherche Aéronautique*, Jan.-Feb., 1956, pp. 17–22. In French. Study of the problem of semi-infinite plates in viscous flow.

**On the Stability of Vortex Streets.** U. Domm. *Tech. U., Berlin-Charlottenburg, Hermann Föttinger-Inst. Strömungstech. TN 56–27*, Oct., 1955. 22 pp. 22 refs. Demonstration of the instability of the von Kármán vortex street even in the case of the classical condition $h/l = 0.281$.

**Determination of Vortex Paths by Series Expansion Technique with Application to Cruciform Wings. Appendix A—Wall-Interference Corrections.** Alberta Y. Alksne. *U.S., NACA TN 3670*, Apr., 1956. 40 pp. Calculation of vortex positions behind a slender equal-span cruciform wing at any angle of bank as a function of the distance behind the trailing edge.

**Flow in a Viscous Vortex.** C. Desmond Pengelley. *Southwest Res. Inst. Eng. Mech. Dept., Rep. 494C-1 (AFOSR TN 56–162)*, Mar. 16, 1956. 59 pp. Derivation of equations for velocity, temperature, and pressure distribution in a two-dimensional viscous vortex with a steady-state component of radial flow, assuming a small radial velocity, as compared with the tangential component, and neglecting the heat transfer.

**Hypersonic Studies of the Leading Edge Effect on the Flow Over a Flat Plate.** A. G. Hammitt and S. M. Bogdonoff. *Jet Propulsion*, Apr., 1956, pp. 241–246. 20 refs. USAF-sponsored experimental investigation in the Princeton helium hypersonic wind tunnel, using optical technique to measure the shock shapes and pressure distribution over a wide range of Reynolds Numbers and leading-edge thicknesses.

**Écoulement Autour de Pointes Émergentes d'Entrées d'Air Supersoniques.** J. Nicolas. *La Recherche Aéronautique*, Jan.-Feb., 1956, pp. 23–26. In French. Development of a method for the calculation of supersonic flow around emerging pointed shapes.

**Transonic Flow Past the Two-Dimensional Wedge with Detached Shock Wave. I.** Akira Takano. *J. Japan Soc. Aero. Eng.*, Feb.-Mar., 1956, pp. 6–12. Analytical solution of the Tricomi equation for the stream function, subject to the boundary conditions prescribed along the axis of symmetry, the wedge surface, the sonic line, and the shock polar in the small disturbance plane.

**Der gegenseitige Einfluss zwischen einem geraden Flügel und einem Rumpf bei Nullauftrieb im Überschallgebiet.** J. F. Vandrey. *ZFW*, Jan.-Feb., 1956, pp. 44–46. In German. Derivation of a simple formula for the interference wave drag in a combination of a straight wing with a fuselage, valid for moderate supersonic Mach Numbers. The formula indicates that the slender-body theory result in a wave drag of the fuselage alone, which is independent of the Mach Number, and that the wave drag of an aircraft can be reduced at low supersonic Mach Numbers by indenting the fuselage in the region of the wing root.

**The Zero-Lift Drag of Full and Half Models of a Body of Revolution at $M = 1.6$.** J. A. Van Der Bliek. *Canada, NAE Note 11 (LR-139)*, 1955. 31 pp. Measurements in the 10- by 10-in. and 30- by 16-in. wind tunnels for Reynolds Numbers from 2.8 to 6 million, using different methods of boundary-layer flow visualization and artificial transition, and a study of the effect of tunnel wall boundary-layer shim thickness on half models.

**Über den Kompressibilitätseinfluss bei und nahe Machzahl Eins für Körper kleiner Streckung und schlanke Rotationskörper.** Friedrich Keune. *ZFW*, Jan.-Feb., 1956, pp. 47–53. 14 refs. In German. Generalization of the slender body theory in subsonic and supersonic flow and of the Oswatitsch-Keune theory for the flow around bodies of revolution at $M = 1$, with an approximation of the nonlinear term of the gas dynamic equation indicating the influence of compressibility near and at $M = 1$, which depends on the velocity gradient on the body at sonic speeds.

**Arrangement of Fusiform Bodies to Reduce the Wave Drag at Supersonic Speeds.** Morris D. Friedman and Doris Cohen. *U.S., NACA Rep. 1236*, 1955. 8 pp. 11 refs. Supt. of Doc., Wash. $0.15. Study of the wave drag of a system of fusiform bodies at zero angle of attack and supersonic speed, using the linearized slender-body theory and reverse-flow theorems to determine the effect of varying the relative location of the component parts.

**Étude Théorique de la Résistance à l'Avancement d'un Corps de Révolution Effilé et Pointu Mis Instantanément en Mouvement dans un Fluide au Repos.** P. Bévierre and P. Diringer. *La Recherche Aéronautique*, Jan.-Feb., 1956, pp. 5–10. In French. Theoretical investigation of the resistance of a tapered, sharp-nosed body of revolution instantaneously set in motion in a fluid at rest.

**Calculations of the Rate of Thermal Dissociation of Air Behind Normal Shock Waves at Mach Numbers of 10, 12, and 14.** George P. Wood. *U.S., NACA TN 3634*, Apr., 1956. 40 pp. 21 refs. Analysis of thermal dissociation between a Mach Number range, covering a temperature range below which little dissocation occurs and a temperature above which electronic excitation and ionization may occur.

**The Character of the Equilibrium of a Heavy, Viscous, Incompressible, Rotating Fluid of Variable Density. I—General Theory. II—Two Special Cases.** Raymond Hide. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 22–50. 10 refs.

**Influence of the Leading-Edge Shock Wave on the Laminar Boundary Layer at Hypersonic Speeds. Appendix—Existence of Distinct Viscous and Inviscid Flow Regions.** Lester Lees. *J. Aero. Sci.*, June, 1956, pp. 594–600, 612. USAF-Army-supported investigation of the shock-wave heating and vorticity

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mode for two cases of steady flow over semi-infinite, insulated flat plates, one with a sharp leading edge, and the other with a blunt leading edge.

**Detonation Wave Fronts in Ideal and Nonideal Detonation.** Melvin A. Cook, G. Smoot Horsley, Robert T. Keyes, William S. Partridge, and Wayne O. Ursenbach. *J. Appl. Phys.* Mar., 1956, pp. 269–277. ONR-sponsored presentation of extensive wave-shape data for various unconfined explosives over wide ranges of diameter, length, density, and physical conditions.

**Tables Pour la Détermination des Ondes de Choc Détachées.** H. Cabannes. *La Recherche Aéronautique*, Jan.–Feb., 1956, pp. 11–15. In French. Development of a method to determine detached shock waves near a body of revolution in uniform supersonic flow parallel to the axis of revolution at $M = 2$.

**On the Vortices Produced in Shock Diffraction.** L. N. Howard and D. L. Matthews. *J. Appl. Phys.*, Mar., 1956, pp. 223–231. Theoretical and experimental investigation of a vortex produced by a weak shock passing over a 5° vertical wedge. Application of the theory to any vortex having a certain rotational symmetry in isentropic flow and expanding uniformly in time without consideration of how the vortex was formed.

**Aerodynamics at Very High Altitudes.** S. A. Schaaf. *Jet Propulsion*, Apr., 1956, pp. 247–250. 19 refs. USAF-ONR-sponsored review of investigations carried out in a low-density supersonic wind tunnel at the U. of Calif. during the period from 1952–1955.

**On Supersonic Rotational Flow Behind Strong Shock Waves. I—Flow Past Airfoils.** Abraham Kogan. *Technion Res. Devel. Found., Haifa, TN (AFOSR TN-56-165)*, 1956. 58 pp. 17 refs. Development of a method of successive approximations to the ideal flow past airfoils at high supersonic Mach Numbers.

**Recent Advances in the Knowledge of Transonic Air Flow.** C. H. E. Warren. *J. RAeS*, Apr., 1956, pp. 241–252. 30 refs. Analysis of the small perturbation theory and its application to cross coupling between the effect of thickness and of incidence, to camber and twist, to the solution of the transonic small perturbation equations, to flow patterns in the transonic range, and to sonic line and shock-wave movements.

**Cavitation of Surface Roughnesses.** K. K. Shalnev. (*Zhur. Tekh. Fiz.* No. 2, 1951, pp. 206–220.) *U.S., Navy Dept., David W. Taylor Model Basin, Transl. 259*, Dec., 1955. 25 pp. 20 refs. Results of experimental studies, utilizing standard techniques in water-tunnel tests of roughness models, to investigate the region of cavitation. Formulation of a hypothesis, taking into account the inception of cavitation on the axis of the vortices in the region of separated flow behind the roughness when the vortex attains its maximum diameter, with a determination of the effect of the boundary layer on the excitation of cavitation of surface roughnesses.

**Diffusion in a Fluid in Turbulent Motion.** G. K. Batchelor. *Appl. Mech. Rev.*, Mar., 1956, pp. 89–91. 15 refs. General review of investigations covering the cases of homogeneous turbulence, shear flow with partial homogeneity, diffusion from a maintained source in shear flow, and the relative diffusion of marked fluids.

**On Strong Transverse Waves Without Shocks in a Circular Cylinder.** Stephen H. Maslen and Franklin K. Moore. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Paper.*) *J. Aero. Sci.*, June, 1956, pp. 583–593. 11 refs.

*Internal Flow*

**Analysis of Gas Flow Systems for Dynamic Control Purposes.** Appendix I—**Compressible Flow Through a Control Valve.** Appendix II—**Determination of the Transfer Function of a Typical Gas Flow System.** Appendix III—**Numerical Calculation of the Response of a Simple System.** W. K. McGregor, Jr., D. W. Russell, R. W. Messick, and L. F. Burns. *USAF AEDC TR-55-11*, Apr., 1956. 60 pp.

**An Approximate Treatment of Forced Heat Convection in Laminar Flow Between Parallel Plates.** S. C. R. Dennis and G. Poots. *Appl. Sci. Res., Sect. A*, No. 6, 1956, pp. 453–457.

**Potentialwirbel-Gitter für Überschallgeschwindigkeiten.** Klaus Oswatitsch. *ZFW*, Jan.-Feb., 1956, pp. 53–57. In German. Definition of the change from parallel flow with various Mach Numbers into potential flow vorticity, applicable to the construction of potential flow vortex cascades with arbitrary Mach Number at the intake and exit, and of arbitrary deflection.

**Flat Plate Cascades at Supersonic Speed.** Rashad M. El Badrawy. (*ETH Inst. für Aerodynamik, Zurich, Mitteil. No. 19*, 1952.) *U.S., NACA TM 1369*, May, 1956. 130 pp. Translation. The analysis includes calculations of lift and drag coefficients for the flat plate at Mach Numbers ranging from 1.2 to 10 and at different angles of incidence, taking into account the exact flow over both sides of the plate.

**Randverluste in Pumpengittern.** Hermann Schlichting. *ZFW*, Jan.-Feb., 1956, pp. 35–40. 14 refs. Results of test measurements of flow losses in compressor cascades for the incompressible case and, in two-dimensional flow, obtained by applying suction to the walls, of the effect of secondary flow along the walls on the pressure rise in the cascade as well as on the deflection of the flow for the ratio of blade length to blade chord $h/l = 3$.

**Some Effects of Guide-Vane Turning and Stators on the Rotating Stall Characteristics of a High Hub-Tip Ratio Single-Stage Compressor.** Eleanor L. Costilow and Merle C. Huppert. *U.S., NACA TN 3711*, Apr., 1956. 52 pp. 15 refs. Experimental investigation using a constant-temperature hot-wire anemometer system to measure flow fluctuations and a calibrated inductance-type pressure pickup in the compressor casing to measure pressure fluctuation.

**Strömung vor einem Überschall-Laufrad.** H. Söhngen. *DVL Bericht 11*, Dec., 1955. 23 pp. Experimental investigation of the flow directed axially at supersonic velocity through a supersonic axial compressor consisting only of a rotor taking into account the reflections of the turbulence caused by the rotating grids.

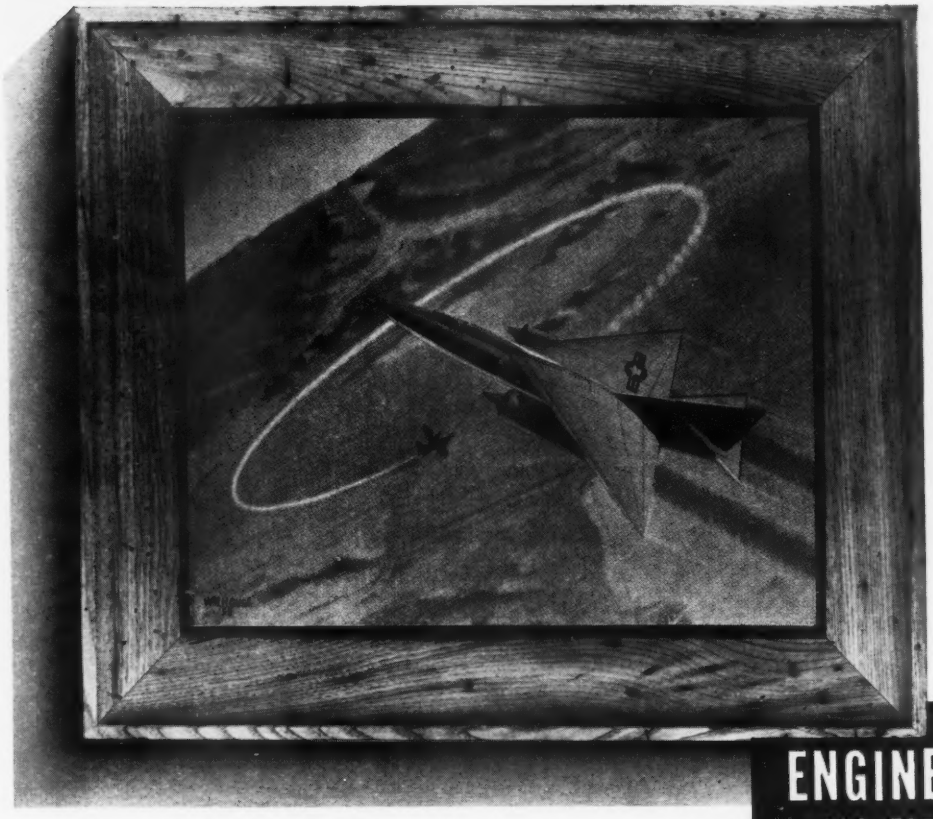
**Air-Turbine Drives—Performance and Limitations.** L. Royce. *Elec. Eng.*, Apr., 1956, pp. 338–343. Analysis of operating requirements and design specifications taking into account air-cruise and ground-idle conditions, and fixed and variable nozzle area. Includes a comparison of turbine configurations and control system response rates.

**Über spezielle Systeme von Tragflügelgittern. II—Theorie der dünnen Profile.** K. Nickel. *Ing.-Arch.*, No. 2, 1955, pp. 102–118. In German. Includes a study of the special case of plane jet flow with calculations for the ordinary and alternating type cascades, the use of Truckenbrodt and Riegel theories to section cascades, and an evaluation of the applicability of the linear theory for profiles of finite thickness.

**On the Gas Dynamics of a Rotating Impeller.** A. Busemann. (*ZAMM*, Feb., 1938, pp. 31–38.) *U.S., NACA TM 1385*, Mar., 1956, 16 pp. Translation. Analysis using an illustrative example of the plane impeller. Indications are that, in a gas flow with constant entropy as in an incompressible flow, the pressure head of a rotating impeller depends only on the circulation around the blades; that, for an impeller rotating freely in an infinite gas mass, a torque larger than that required for the pressure rise can be obtained; and that the finite energy of travelling sound waves produces a resistance which grows with a high initial power of the circumferential velocities and, when sonic velocity is exceeded, gradually becomes the wave resistance of bodies moved rectilinearly at supersonic velocity.

**Analysis of Reynolds Number Effects in Fluid Flow Through Two-Dimensional Cascades.** D. J. K. Stuart. *Gt. Brit., ARC R&M 2920* (July, 1952), 1955. 39 pp. 16 refs. BIS, New York. $2.40. Approximate mathematical investigation, with detailed study of the laminar and turbulent boundary-layer separation as sources of low efficiency. The tests were carried out in conjunction with, and supported by, results of an extensive testing program in the Cambridge U. Eng. Lab low-speed wind tunnel.

**Theoretical Loss Relations for Low-Speed Two-Dimensional-Cascade Flow. Appendix—Loss Coefficient for Complete Mixing.** Seymour Lieblein and William H. Roudebush. *U.S., NACA TN 3662*, Mar., 1956. 46 pp. 13 refs. Analysis, for incompressible flow, of the relations between total-pressure defect and wake momentum thickness. Development of equations for total-pressure-loss coefficient, both in an arbitrary downstream plane and in a plane far downstream where complete mixing occurs, in terms of wake momentum thickness and form factor at the arbitrary plane. Results indicate that the total-pressure-loss coefficient for unseparated flow varies almost directly with the solidity and the ratio of wake momentum thickness to blade chord length and inversely with the cosine of the air outlet angle.



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**Flow of Gas Through Turbine Lattices.** M. E. Deich. *U.S., NACA TM 1393*, May, 1956. 136 pp. 23 refs. (Translation of chapter 7 of Tekhnicheskaia Gazodinamika; Moscow, Gosenergoizdat, 1953.) Study of the fluid mechanics of turbine cascades, with fundamental characteristics of lattices and of the flow through lattices, applying the Joukowsky theorem. Includes electrohydrodynamic analogy, forces acting on an airfoil in a lattice, friction and edge losses in plane lattice at subsonic velocities, profile losses in lattices at large subsonic velocities, flow of a gas through reaction lattices at supersonic pressure drops, impulse lattices in supersonic flow, and losses in lattices at near-sonic and supersonic velocities.

**An Approximate Method of Calculating Three-Dimensional Compressible Flow in Axial Turbomachines.** Carl O. Holmquist and W. Duncan Rannie. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Paper.*) *J. Aero. Sci.*, June, 1956, pp. 543–556, 582. Extension of the approximate methods of calculating incompressible flow in compressors with constant blade height, assuming that the blades are completely defined by the exit flow angle and neglecting the influence of downstream blades. Examples illustrate the flexibility and practical value of the described method and the rapid convergence of successive solutions.

**Three-Dimensional Flow in Axial-Flow Turbomachinery. I—Theoretical Determination of Secondary Flow. Appendix A—Additional Axi-Symmetric Relationships. Appendix B—Determination of the Time Required for Particles to Traverse Airfoils. II—Experimental Investigations.** Leroy H. Smith, Jr. *USAF WADC TR 55-348*, Aug., 1955. 124 pp. 41 refs. Theoretical and experimental investigation of secondary flow in turbomachinery, using the conventional axial symmetric solution from which induced turning and radial velocity characteristics of secondary flow can be deduced. Tests were also run to provide inlet guide vane and rotor performance over a range of operation varying from incipient stall to maximum throttle opening.

**Observations on the Surging of Various Low-Speed Fans and Compressors.** A. G. Smith and P. J. Fletcher. *Gt. Brit., NGTE Memo. M. 219*, July, 1954. 30 pp. Analysis of surge phenomena of four types: with a rotating localized reverse or disturbed flow region; with violent, nonrotating oscillations; with distributed reverse flow at blade tips; and with "anchored" localized reverse flow.

**Bestimmung des Verhältnisses der Austauschkoeffizienten für Wärme und Impuls bei turbulenten Grenzschichten.** Hubert Ludwieg. *ZFW*, Jan.-Feb., 1956, pp. 73–81. 13 refs. In German. Investigation for the determination of the ratio of heat and momentum coefficient exchange as a function of the radius for fully developed turbulent incompressible flow through pipes, calculated from the measured velocity profile, the stagnation temperature profile, and the flow of energy due to diffusion of turbulent fluctuating energy.

**Discharge Coefficients for Combustor-Liner Air-Entry Holes. I—Circular Holes with Parallel Flow.** Ralph T. Dittrich and Charles C. Graves. *U.S., NACA TN 3663*, Apr., 1956. 39 pp. 10 refs. Experimental investigation to determine the effects of various geometric and flow factors on the discharge coefficients, including hole diameter, wall thickness at the hole, parallel-flow duct height, boundary-layer thickness, parallel-flow velocity, static-pressure level, and pressure ratio across the test hole.

**Luftströmungen mit Drall im Kreisrohr hinter radialem Leitapparat.** W. Schiebeler. *Max-Planck-Inst. für Strömungsforschung, Mitteil. No. 12*, 1955. 101 pp. 16 refs. In German. Study of the problem of rotating flow in a cylindrical tube, with a determination of the velocity distribution from pressure, angle, and temperature measurements.

**Further Investigation of Laminar Flow in Channels with Porous Walls.** S. W. Yuan. *J. Appl. Phys.*, Mar., 1956, pp. 267–269. Extension of the problem of two-dimensional steady-state laminar flow to the case of moderate-to-high suction or injection velocity at the walls. Includes calculation of an exact solution of the Navier-Stokes equations reduced to a third-order nonlinear differential equation with appropriate boundary conditions; and velocity components, pressure, and coefficient of wall friction expressed as functions of the velocity through the porous wall, the average axial velocity of the Poiseuille flow, the coordinates and dimensions of the channel, and the physical properties of the fluid.

**Model Tests on the Asymmetry of Airflow Occurring in Twin-Intake Systems at Subsonic Speeds.** J. Seddon and W. J. G. Trebble. *Gt. Brit., ARC R&M 2910* (Feb., 1951), 1955. 15 pp. BIS, New York. $1.15. Results of wind-tunnel tests on a pair of wing-root leading-edge intakes and on various arrangements of body-side submerged intakes indicate the presence of a region of flow asymmetry and the appropriate flow coefficients outside the main intake working range, similar to those encountered in a dive or in throttling back in level flight.

**An Approximate Solution of Compressible Turbulent Boundary-Layer Development and Convective Heat Transfer in Convergent-Divergent Nozzles.** D. R. Bartz. *Trans. ASME*, Nov., 1955, pp. 1,235–1,245. 24 refs. Includes derivation of an expression for the local heat-transfer coefficient as a function of boundary-layer thicknesses and determination of the effects of nozzle size and throat radius of curvature for similar nozzle contours in common use, with the results demonstrated by a sample calculation.

**The Axial Decay and Radial Spread of a Supersonic Jet Exhausting Into Air at Rest.** J. H. Frauenberger and J. G. Forbister. *Gt. Brit., RAE Rep. RPD 34*, Dec., 1955. 32 pp. Measurements of the distribution of total pressure, stagnation temperature, and gas velocity, in the subsonic region, of a jet emerging from a solid-propellant rocket motor into air at rest, and of the pitot pressures in the supersonic flow region. It is shown that the flow follows the axis of an inclined nozzle, and that the nozzle cone angle and the expansion region affect the jet distribution.

### *Performance*

**Analysis of a Rolling Pull-Out Maneuver.** W. J. Oakes, Jr., and P. T. Holliday. *J. Aero. Sci.*, June, 1956, pp. 517–529. 11 refs. Evaluation of four methods to predict the vertical-tail angle of attack and the corresponding load, with numerical solutions for three airplane configurations including the straight-, swept-, and delta-wing, in order to define more precisely the attitudes of the airplane.

### *Stability & Control*

**Analysis of a Vane-Controlled Gust-Alleviation System.** Robert W. Boucher and Christopher C. Kraft, Jr. *U.S., NACA TN 3597*, Apr., 1956. 45 pp. Theoretical study, using an electronic analog computer, of the response to step gusts of an aircraft equipped with a system in which modified wing flaps and a modified elevator are operated to reduce accelerations in rough air, and of the effect of interconnection of the flap-operating mechanism with the pilot's control system.

**Effects of Wing Position and Fuselage Size on the Low-Speed Static and Rolling Stability Characteristics of a Delta-Wing Model.** Alex Goodman and David F. Thomas, Jr. *U.S., NACA Rep. 1224*, 1955. 31 pp. 20 refs. Supt. of Doc., Wash. $0.30. Results of an experimental investigation indicate that, for the longitudinal-stability case, for all wing positions, the maximum lift coefficient decreases with the increasing fuselage size; and, for the lateral-stability case, the vertical-tail lift-curve slope and the effective dihedral increase with the increasing fuselage size.

**Determination of Lateral-Stability Derivatives and Transfer-Function Coefficients from Frequency-Response Data for Lateral Motions. Appendix A—Development of Equations for Transfer Functions, Modes, and Frequency Response for Lateral Motion. Appendix B—Determination of Lateral-Stability Derivatives by Use of Frequency Responses Derived from Calculated Transient Responses to Aileron Deflection. Appendix C—Least-Squares Vector Solution of the Equations of Lateral Motion.** James J. Donegan, Samuel W. Robinson, Jr., and Ordway B. Gates, Jr. *U.S., NACA Rep. 1225*, 1955. 19 pp. Supt. of Doc., Wash. $0.25.

**Theoretical and Analog Studies of the Effects of Nonlinear Stability Derivatives on the Longitudinal Motions of an Aircraft in Reponse to Step Control Deflections and to the Influence of Proportional Automatic Control.** Howard J. Curfman, Jr. *U.S., NACA Rep. 1241*, 1955. 21 pp. 19 refs. Supt. of Doc., Wash. $0.25.

### *Wings & Airfoils*

**Äquivalenzsatz, Ähnlichkeitssätze für schallnahe Geschwindigkeiten und Widerstand nicht angestellter Körper kleiner Spannweite.** Friedrich Keune and Klaus Oswatitsch. *ZAMP*, Jan. 25, 1956, pp. 40–63. 11 refs. In German. Includes similarity laws for low aspect ratio wings using a corresponding similarity law for bodies of revolution.

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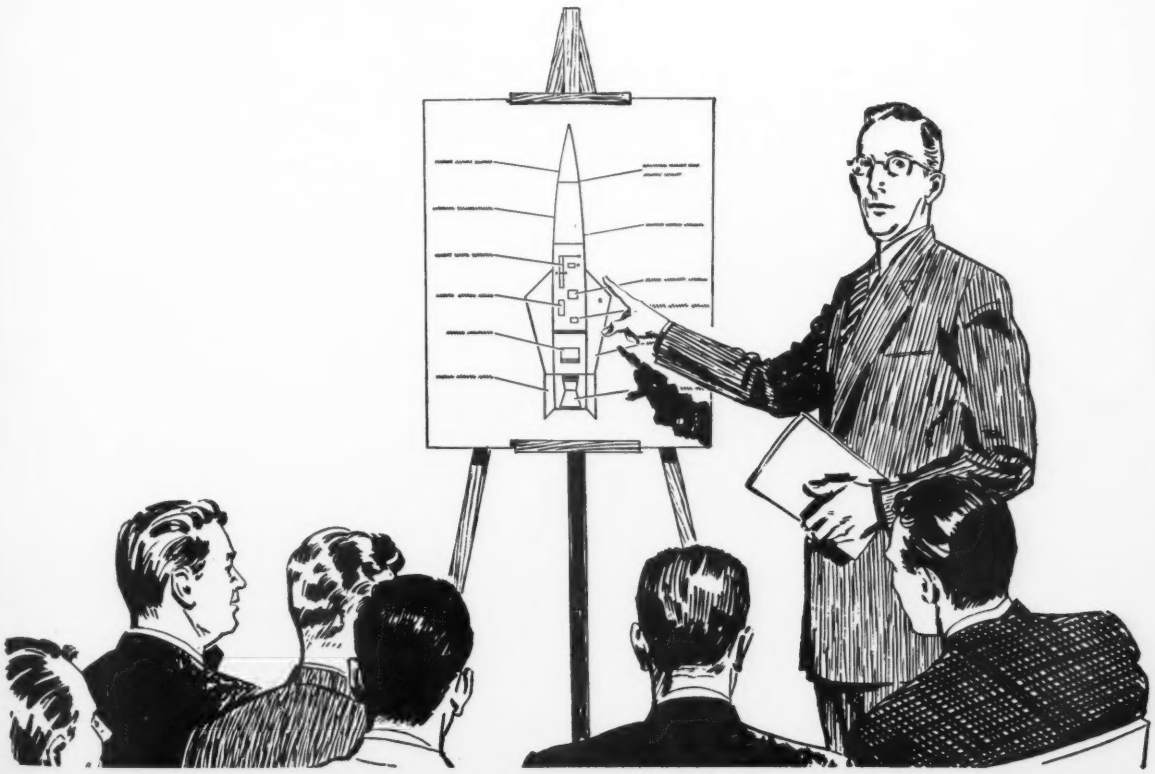

**aus der Druckverteilung.** R. Eppler. *Ing.-Arch.*, No. 6, 1955, pp. 436–452. 14 refs. In German. Development of a method for the calculation of airfoil profiles with given velocity distribution, taking into account the boundary-layer phenomena.

**The Calculation of the Loading and Pressure Distribution on Cranked Wings.** G. G. Brebner. *Gt. Brit., ARC R&M 2947* (Jan., 1953), 1955. 31 pp. 20 refs. BIS, New York. $1.80. Derivation of approximate formulas, which can be extended to the subcritical compressible flow by considering the "analogous wing," and which utilize distributions of vortices and sources over the airfoil surface.

**Sur l'Influence du Fuselage sur l'Aile et l'Empennage Vertical aux Grandes Vitesses.** Svetopolk Pivko. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 387–394. In French. Analysis of the fuselage effects on aerodynamic characteristics of wings and vertical tail planes.

**Effect of Thickness, Camber, and Thickness Distribution on Airfoil Characteristics of Mach Numbers up to 1.0.** Bernard N. Daley and Richard S. Dick. *U.S., NACA TN 3607*, Mar., 1956. 75 pp. 17 refs. Results of tests of a group of related NACA airfoil sections varying in maximum thickness, design lift coefficient, and thickness distribution in a two-dimensional open-throat wind tunnel at Mach Numbers of 0.3 to approximately 1.9, and at corresponding Reynolds Numbers from $0.7 \times 10^6$ to $1.6 \times 10^6$. Includes calculations of normal-force, drag, and pitching-moment coefficients, with schlieren photographs and pressure-distribution diagrams.

**Theoretical Prediction of Pressure Distributions on Nonlifting Airfoils at High Subsonic Speeds.** Appendixes A, B—**Discussion of Certain Properties of the Quadratic Iteration Method.** *U.S., NACA Rep. 1217*, 1955. 42 pp. 40 refs. Supt. of Doc., Wash. $0.40.

**An Analysis of Estimated and Experimental Transonic Downwash Characteristics as Affected by Plan Form and Thickness for Wing and Wing-Fuselage Configurations.** Joseph Weil, George S. Campbell, and Margaret S. Diederich. *U.S., NACA TN 3628*, Apr., 1956. 92 pp. 29 refs. Summary of data obtained from eleven transonic-bump investigations over a Mach Number range of 0.6 to 1.1. Experimental results are compared with those of theoretical calculations for subsonic and supersonic Mach Numbers.

**A Theoretical Study of the Aerodynamics of Slender Cruciform-Wing Arrangements and Their Wakes.** John R. Spreiter and Alvin H. Sacks. *U.S., NACA TN 3528*, Mar., 1956. 67 pp. 19 refs. Application of the slender-body theory, with equations formulated for the pressures, loadings, and forces on slender cruciform wings and wing-body combinations. Includes an investigation of the rolling-up of the vortex sheet behind a slender cruciform wing and a numerical analysis using 40 vortices to calculate the wake shape at various distances behind an equal-span cruciform wing at 45° bank. Development of analytical expressions for the corresponding positions of the rolled-up vortex sheets using a four-vortex approximation to the wake compared with the positions of the centroids of vorticity.

**The Effect of Dihedral on the Lift and Drag Coefficients of Airfoils in Supersonic Flow.** J. B. L. Powell. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 51–74. Investigation of the pressure distribution on the surface of a dihedral wing for varying angles of sweepback and Mach Numbers, with a solution obtained by the linearized theory under the assumption that the angles of incidence and yaw are small, and with graphical results for a delta wing.

**An Investigation of the Maximum Lift of Wings at Supersonic Speeds.** James J. Gallagher and James N. Mueller. *U.S., NACA Rep. 1227*, 1955. 28 pp. Supt. of Doc., Wash. $0.30. Results of tests in the Langley 9-in. supersonic tunnel on eleven different wing plan forms of random thickness distribution at Mach Numbers of 1.55, 1.90, and 2.32 and at Reynolds Numbers varying between $0.74 \times 10^6$ and $0.27 \times 10^6$, at angles of attack ranging from zero up through the angle at which maximum lift occurs. Subsequent pressure-distribution tests on wings of rectangular and triangular plan forms at $M = 2.40$ substantiate the values of maximum lift obtained during force tests and indicate no appreciable center-of-pressure shift over the entire angle-of-attack range.

**Measurement of Lift, Pitching Moment, and Hinge Moment on a Two-Dimensional Cambered Aerofoil to Assist the Estimation of Camber Derivatives.** H. C. Garner and A. S. Batson. *Gt. Brit., ARC R&M 2946* (Dec., 1952), 1955. 34 pp. 10 refs. BIS, New York. $2.00.

**Der nichtlineare Auftriebsanstieg von Rechteckflügeln sehr kleinen Seitenverhältnisses.** Dietrich Küchemann. *ZFW* Jan.-Feb., 1956, pp. 70–73. 10 refs. In German. Analysis of the nonlinear rise of the overall lift with the angle of incidence of rectangular wings in incompressible flow, occurring during separation; various simplified models to represent flows; and methods to estimate the lift.

**Optimum Thickness and Lift Distribution for a Fuselage in the Presence of a Prescribed Wing System.** M. E. Graham. *Douglas Rep. SM-19615 (Revised)*, Mar., 1956. 8 pp. 11 refs.

**Results of a Flight Investigation to Determine the Zero-Lift Drag Characteristics of a 60° Delta Wing with NACA 65-006 Airfoil Section and Various Double-Wedge Sections at Mach Numbers from 0.7 to 1.6.** Clement J. Welsh. *U.S., NACA TN 3650*, Apr., 1956. 13 pp.

**A First-Order Formulation of the Unsteady Supersonic Flow Problem for Finite Wings.** John W. Miles. *J. Aero. Sci.*, June, 1956, pp. 578–582.

**A Method for the Design of Sweptback Wings Warped to Produce Specified Flight Characteristics at Supersonic Speeds.** Warren A. Tucker. *U.S., NACA Rep. 1226*, 1955. 17 pp. Supt. of Doc., Wash. $0.20. Development of a procedure for controlling the location of the center of pressure and the pitching moment, applicable to several wing plan forms, including the triangle and sweptback wings with finite tops, under the assumption that the leading edge is subsonic and the trailing edge is supersonic. Includes calculations of values of the coefficients of a four-term series (used to determine the required warp), which describes the pressure distribution determined from four conditions of the lift, pitching moment, and spanwise load distribution.

**Zur Aerodynamik des Ringflügels in inkompressibler Strömung.** Johannes Weissinger. *ZFW*, Mar.-Apr., 1956, pp. 141–150. In German. Development of a method for the calculation of the pressure distribution over thin and nearly axisymmetrical annular wings in incompressible flow.

**Linearized Lifting-Surface and Lifting-Line Evaluations of Sidewash Behind Rolling Triangular Wings at Supersonic Speeds.** Appendix A—**Treatment of First-Order Infinities in $v_{P,E}$ as Given by Equation (20).** Appendix B—**Evaluation of $v_{W,D}$.** Percy J. Bobbitt. *U.S., NACA TN 3609*, Mar., 1956. 63 pp. 18 refs.

**Theoretical Pressure Distributions for Some Slender Wing-Body Combinations at Zero Lift.** Paul F. Byrd. *U.S., NACA TN 3674*, Apr., 1956. 39 pp. 13 refs. Calculation of the pressure distribution for both subsonic and supersonic speeds on slender, swept wings alone, with constant chord and tip, and on combinations, where the wing is mounted on a circular cylinder or combined with a body indented such that the axial variation of cross-sectional area of the combination is constant. Included are the effects of Mach Number and sweep angle.

**Zero-Lift-Drag Characteristics of Wing-Body Combinations at Transonic Speeds.** Richard T. Whitcomb. (*IAS 24th Annual Meeting, New York, Jan. 23–26, Preprint 601.*) *Aero. Eng. Rev.*, June, 1956, pp. 42–45.

## Aeroelasticity

**Aeroelastic Problems of Low Aspect Ratio Wings. III—Aerodynamic Forces on an Oscillating Delta Wing.** J. Leyds. *Aircraft Eng.*, Apr., 1956, pp. 119–122. 11 refs.

**Models for Aero-Elastic Investigations.** H. Templeton. *Gt. Brit., RAE TN Struc. 179*, Nov., 1955. 22 pp. Derivation of scale relationships in the design of prediction models with which the aerodynamic, structural, and dynamic characteristics of flutter phenomena can be reproduced.

**Une Transformation des Systèmes des Équations de L'Élasticité.** Miroslav Nenadovitch. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 384–386. In French. Transformation of systems of elasticity equations incorporating Navier, Cauchy, and Hooke equations.

**La Technique des Essais de Vibration au Sol.** R. Mazet. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 395–399. In French. Development of a technique applied to ground vibration tests of airplanes.

**Some Effects of Fuselage Flexibility on Longitudinal Stability and Control.** Appendix A—**Calculation of Potential Strain Energy.** Appendix B—**Derivations of Tail and Wing Angles of Attack.** Ap-

(*Continued on page 150*)

# INTERNATIONAL AERONAUTICAL ABSTRACTS

## A Review of Worldwide Scientific and Technical Literature

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### ACOUSTICS, SOUND, & NOISE

A FLIGHT TEST INVESTIGATION OF THE SONIC BOOM. M. E. Mullens. USAF FTC TN-56-20, May, 1956. 35 pp. Results of tests to obtain time histories of the variation in static pressure caused by the shock waves of an F-100 aircraft instrumented for static pressure measurements through the shock waves generated by a second F-100. Tests include: fly-by passes made to the right of and below the generating aircraft at an altitude of 35,000 ft. and a Mach Number of 1.05, with the separation distance between the two aircraft varying from 100 to 2,000 ft.; passes made below the generating aircraft at 25,000 ft. and at Mach Number 1.05, with the separation distance varying from 200 to 1,000 ft.; an unsuccessful attempt to record pressure rise during high Mach Number dive; and additional flights made over a ground station from stabilized level flight at altitudes of 20,000, 30,000, and 40,000 ft., to determine the audibility of the sonic boom as a function of Mach Number and altitude. Data indicate that the initial rate of decay of the shock wave pressure jump versus distance is quite large and is in accordance with the Whitham theory for supersonic flow past a body of revolution; the pressure rise, a function of free stream static pressure, can be expected to be as much as 60 pounds per sq. ft. for very-low-level supersonic flight, implying a high possibility of widespread public disturbance and damage; high Mach Number passes are potential safety hazards; sonic booms audible at ground level can easily be produced during level flight at supersonic speed and in some cases during shallow supersonic climbs; and the occurrence of the sonic boom at ground level is dependent upon the prevailing atmospheric conditions, causing difficulties in prediction.

### AERODYNAMICS

RÓWNANIE BOLTZMANNA I JEGO ZNACZENIE W TEORII GAZÓW. Zdzisław Szymański. Rozprawy Inżynierskie (Warsaw), No. 4, 1955, pp. 501-553. 39 refs. In Polish, with summaries in English and Russian. Analysis of gas phenomena using phenomenological hydrodynamics, kinetic theory, and statistical mechanics. Fundamental assumptions of the kinetic theory of gases are represented by the kinetic distribution function. Boltzmann equation is solved by the Maxwell velocity distribution law, and the Enskog-Chapman-Burnett theory is used to determine kinetic coefficients. The problem of irreversibility of equations of the kinetic theory of gases is discussed in connection with the reversibility of the equations of mechanics, and the Grad method of solution for the Boltzmann equation by mean of an expansion in a series of Hermite's three-dimensional polynomials is represented. The Boltzmann equation is applied to shock wave investigation and an effort is made to generalize the Boltzmann equation and the kinetic theory.

#### Aerothermodynamics

MEASUREMENT OF RECOVERY FACTORS AND HEAT TRANSFER COEFFICIENTS WITH TRANSPIRATION COOLING IN A TURBULENT BOUNDARY LAYER AT M = 3 USING AIR AND HELIUM AS COOLANTS. Appendix A - EXTENSION OF FILM THEORY TO DIFFUSION CASES WHERE THE FRACTIONAL CONCENTRATION OF FOREIGN GAS AT THE WALL DIFFERS FROM UNITY. B.M. Leadon and C.J. Scott. U. Minn., Inst. Tech. Dept. Aero. Eng. Res. Rep. 126, Feb., 1956. 32 pp. OSR-sponsored investigation of cooling effects on a flat plate with a turbulent boundary layer, by the introduction into the boundary layer by means of a porous wall, of liquids and light gases having kinetic and thermal properties different from those of the free stream gas. Results indicate that strong mass-transfer cooling effects in a turbulent boundary layer are possible at M = 3, and reduce heat transfer coefficients below laminar values at the higher blowing velocities. Recovery factors based on temperature have been reduced by 30% through the injection of only 0.2% helium into the free-stream mass flow. The heat transfer coefficient is also reduced by 90%

for these same conditions. Measured data correlates well with the Rubesin compressible theory for air and qualitatively with simple film theory for either coolant.

THE TEMPERATURE OF MATERIALS AT HIGH FLIGHT SPEEDS AND THE PROBLEMS INVOLVED. A.S. Hartshorn. Gt. Brit., RAE TN Aero. 2397, Sept., 1955. 30 pp. 15 refs. Discussion of kinetic heating encountered in high-speed flight with an outline of problems involved and of the effects of high temperatures on structural design.

THERMAL CONDITIONS ASSOCIATED WITH AIRCRAFT IN FLIGHT. Martin Bloom. USAF WADC TR 55-169, Mar., 1956. 66 pp. 94 refs. Review of developments in the field of forced-convection heat transfer to provide structural specialists with aerodynamic boundary-condition data required to solve temperature-distribution problems. Laminar and turbulent flows are considered for the cases of two-dimensional flat and curved surfaces and for three-dimensional bodies of revolution. Further includes bibliography of source material on aerodynamic heating.

## Boundary Layer

BOUNDARY LAYER BEHIND SHOCK OR THIN EXPANSION WAVE MOVING INTO STATIONARY FLUID. Harold Mirels. US, NACA TN 3712, May, 1956. 53 pp. 13 refs. Investigation of laminar and turbulent boundary layers behind a shock or thin expansion wave and of the wall temperature behind these waves. The laminar problem is solved by numerical integration, with Kármán-Pohlhausen integral solutions used as a guide for determining expressions for the numerical data. The turbulent case is solved using the Blasius equation in a form which accounted for compressibility. Results indicate that for strong shock waves the boundary layer behind the shock will have large temperature gradients normal to the wall, and also that the fluid behind such a wave tends to dissociate.

AN APPROXIMATE THEORY OF TURBULENT BOUNDARY LAYER SHOCK WAVE INTERACTION. A.G. Hammitt. Princeton U. Dept. Aero. Eng. Rep. 340 (OSR TN-56-160), Apr., 1956. 42 pp. 25 refs. Investigation of the shock wave turbulent boundary layer problem in the absence of skin friction and momentum addition from the free stream. The analysis is based on the assumption that momentum and mass are conserved in the boundary layer through the interaction and that the turbulent boundary layer is essentially a one parameter family. Results indicate that: a theory of shock-wave boundary-layer interaction, consistent with available experimental data, can be formulated neglecting external mixing and skin friction; the assumption of a one-parameter boundary layer seems questionable in some of the cases examined; two basic types of oblique shock wave interactions are found which, either alone or in combination, describe most cases of shock boundary layer interactions; and that the limiting pressure ratios and conditions behind the various shock boundary layer configurations can be calculated by the described method, which also permits consideration of the effects of different boundary layer profiles ahead of the interaction region.

UNSTEADY LAMINAR BOUNDARY LAYER OVER A FLAT PLATE IN THE DOWNSTREAM REGION. S.I. Cheng and I.D. Chang. Princeton U. Dept. Aero. Eng. Rep. 339 (AFOSR TN 56-115), Mar., 1956. 24 pp. 11 refs. Analysis of the unsteady flow in an incompressible viscous fluid using the Rayleigh method. Formulas for calculating velocity profiles and skin friction are derived and applied to examples with different boundary conditions. Results show that the Rayleigh-type solution provides a good approximation of the flow field from downstream to the point lying at the middle joint between the instantaneous and the original leading edge position.

FLIGHT TESTING OF A VAMPIRE AIRCRAFT AT MAXIMUM LIFT. P.B. Atkins. Australia ARL FN 23, Aug., 1955. 44 pp. Results of series of flight tests to determine the effect of turbulence strips on boundary layer separation. Tests include an investigation of the general flow over the wingtip, pilot's evaluation of aircraft behavior at stall due to turbulence strips, measurement of wing surface pressures near the leading edge, comparative measurements of the aircraft drag, and boundary layer traverse just ahead of the aileron with and without the fitted strips. Tests show that the thickening of the boundary layer at stall near the leading edge of the control surface is reduced by the addition of strips. Turbulence strips make the aircraft stall behavior consistent at all altitudes, which is reflected by changes in the pressure distribution near the wing leading edge.

## Control Surfaces

ÜBER INDUZIERTE ZIRKULATIONEN. Gustav Viktor Lachmann. ZFW, May-June, 1956, pp. 173-178. In German. Analysis using the method of conformal transformation to show that small circulation carriers of high intensity arranged near the trailing edge of an airfoil can induce circulations of substantial magnitude on the airfoil. Suitable circulation carriers are either small-chord airfoils whose circulation can be intensified by the blow-out technique or sucked porous cylinders fitted with Thwaites flap to fix the rear stagnation point.

## Fluid Mechanics & Aerodynamic Theory

SMALL PERTURBATIONS IN THE UNSTEADY FLOW OF A COMPRESSIBLE, VISCOUS AND HEAT-CONDUCTING FLUID. T. Yao-Tsu Wu. J. Math. & Phys., Apr., 1956, pp. 13-27. 11 refs. ONR-sponsored analysis of fluid flow with small external forces and heat additions which induce small perturbations in the flow field. Consequently, as a first-order approximation, the equations of fluid flow can be linearized. Limited solutions of this linearized system of equations exhibit automatically the

region where viscosity and heat conduction play significant roles. Within the linearized system of equations the concept of longitudinal and transversal waves is generalized to include heat conduction, and a proof is given for splitting the linearized flow into two components. From the definition of these waves compressibility and heat-conduction effects only appear in the longitudinal part. The equations are further simplified after linearization by the assumption that the Prandtl Number is equal to 3/4. The corresponding fundamental solutions are found for both large and small values of time.

ANALYTICAL AND NUMERICAL METHODS FOR HYPERBOLIC CONICAL FLOWS. Roberto Vaglio-Laurin and Nathan Ness. Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 273, July, 1955. 85 pp. OSR-sponsored development of characteristic methods for the analysis of the hyperbolic region. Two modifications of the general method are developed to reduce the amount of numerical work, and the details of their practical application for the determination of the flow field and of the boundary conditions are presented. The linearized characteristic method is extended to conical flow problems and applied to determine the relations between the curvature of a conical body with sharp supersonic edges and the curvature of the attached shock at the leading edge.

UNSTEADY TWO-DIMENSIONAL FLOWS WITH FREE BOUNDARIES. I - GENERAL THEORY. II - INCOMPRESSIBLE INVISCID JET. N. Curle. Proc. Royal Soc. (London), Ser. A, May 8, 1956, pp. 375-395. Investigation of unsteady flow which includes review of earlier work on free-boundary problems, and the initial development of steady two dimensional flows. Method involves transformation from the physical plane to the hodograph plane and is applied to the case of a slit of infinite width which is suddenly opened into a large container with a jet of gas flowing into free space. The shape of the jet after a large but finite time is calculated and the true radius of curvature of the nose is evaluated.

THE FLOW OF A VISCOUS LIQUID PAST A FLAT PLATE AT SMALL REYNOLDS NUMBERS. S. Tomotika and H. Yosinobu. J. Math. & Phys., Apr., 1956, pp. 1-12. Analysis of the skin friction phenomena based on the Davies use of Southwell and Squire equations of motion to obtain an expansion formula in complete agreement with the Piercy and Winny solution. The Davies functions for the solution of the Mathieu equation are modified by certain constant multipliers, these functions being expressed in more rapidly convergent series in products of the modified Bessel functions.

COMPARISON OF THE EXPERIMENTAL AND THEORETICAL DISTRIBUTIONS OF LIFT ON A SLENDER INCLINED BODY OF REVOLUTION AT M = 2. E.W. Perkins and D.M. Kuehn. US, NACA TN 3715, May, 1956. 39 pp. 19 refs. Determination of pressure distributions and force characteristics for a body of revolution consisting of a fineness ratio 5.75, circular-arc, ogival nose tangent to a cylindrical afterbody for an angle of attack range of $0^{\circ}$ to $35.5^{\circ}$, at 1.98 free-stream Mach Number and approximately $0.5 \times 10^{6}$ free-stream Reynolds Number, based on body diameter. Comparison of the theoretical and experimental pressure distributions show that for zero lift, either slender-body theory or higher-order theories yield results which are in good agreement with experiment. For the lifting case, good agreement with theory is found only for low angles of attack and for the region in which the body cross-sectional area is increasing in the down stream direction. The experimental pressure distributions differ from those predicted by potential theory because of the effects of cross-flow separation and of compressibility due to the high cross-flow Mach Numbers at large angles of attack. Further the results indicate that, although the flow is, in general, similar to that assumed as a basis for Allen's method of estimating the forces resulting from viscous effects, the distribution of the forces is different, but that lift and pitching-moment characteristics are in fair agreement with the estimated values.

THE ACCURACY OF THE METHOD OF CHARACTERISTICS. M.G. Hall. Australia, ARL Rep. A.95, Sept., 1955. 31 pp. Theoretical analysis of the mechanism of error propagation for two-dimensional, steady, homentropic, irrotational, supersonic flow of a perfect gas. Consideration of the two inherent error sources: rounding errors introduced throughout and mean slope errors introduced at every step owing to the approximate nature of the difference equations. Additional errors are introduced when the initial conditions of the computation are known only approximately. Results show that even approximate identification of the domain of dependence is impossible with the two Mach line segments converging to the point. Includes a brief summary of the replanning of a computation for the design of a supersonic nozzle, with experimental verification of the developed theory.

ON THE RANGE OF APPLICABILITY OF THE TRANSONIC AREA RULE. J.R. Spreiter. US, NACA TN 3673, May, 1956. 21 pp. Investigation of the range of applicability of the transonic area rule by comparison with the appropriate similarity rule of transonic flow theory and with available experimental data for a large family of rectangular wings having NACA 63AXXX profiles. The use of the transonic area rule for the correlation of the sonic drag-rise data for such a family of wings is illustrated under the assumption that the wing profiles are symmetrical and that the product of the aspect ratio and the cube root of the thickness ratio is less than about unity. Within this range the sonic drag rise varies as the square of the maximum cross-section area, all wings having equal chord. Results also indicate that the area rule is applicable to families of cambered wings if the camber distribution, as well as the area distribution, are similar; and that the ratio of the maximum ordinates of the camber and thickness distribution is maintained constant.

## Internal Flow

ÉCOULEMENT EN AVAL DES DIFFÉRENTES ROUES DIRECTRICES DE TURBINE AVEC ET SANS ROUE MOBILE. David and Luksch. Tech. et Sci. Aéronautiques, No. 1, 1956, pp. 32-35. In French. Results of an experimental investigation to study the flow in turbine blades as function of the blade height, to verify methods of calculation, and to determine possible improvements. The problem of secondary leaks is considered, taking into account the influence of the boundary-layer thickness along the walls and around the profile, and the aerodynamic deviation of the blade. Evaluation of the simplifying hypothesis used in the calculation of the radial equilibrium, admitting the absence of the flow curvature in the meridian surface, which can lead to substantial error is considered. The conclusion points out that it is necessary to avoid the tendency of the flow to rise on the inside wall, which results in the thickening of the boundary layer at the base of the pivoting blade and produces a separation.

NÄHERUNGSFORMELN FÜR DIE ZIRKULATIONSVERTEILUNG UM ENG STEHENDE SCHAUFELN VON STRÖMUNGSGITTERN. Albert Betz. ZFW, May-June, 1956, pp. 166-169. In German. Derivation of equations taking into account the effects of finite blade spacing for blades of infinitely small thickness. In the case of finite distance the distribution of the circulation drops to zero at the end of the cascade and at the entry, when there are no entry losses. Simplifying assumptions are made to derive equations for the infinitely thin blade and for the effect of blade thickness.

ANALYSIS OF VISCOUS INCOMPRESSIBLE AND COMPRESSIBLE FLOWS THROUGH AXIAL FLOW TURBOMACHINES WITH INFINITESIMAL AND FINITE BLADE SPACING. T.P. Torda. USAF WADC TR 55-231, Mar., 1956. 105 pp. 33 refs. Investigation of flow in turbomachines including a review of early work, and presentation of analyses and numerical examples for several variations of viscous flow parameters. The Lorenz channel theory is developed for both compressible and incompressible cases where the flow may be laminar or turbulent, and where the blade spacing is finite or infinitesimal. Analysis consists of an iteration process in which the first step is an evaluation of an equivalent axially symmetric flow field for streamlines of a desired pressure rise and velocity field, which in turn form the first terms of an infinite series for the velocities and pressure.

AN EXPERIMENTAL INVESTIGATION OF A SONIC JET DIRECTED UPSTREAM AGAINST A UNIFORM SUPERSONIC FLOW. G.A. Watts. UTIA TN 7, Jan., 1956. 46 pp. 12 refs. Experimental study of the flow configuration generated by directing a sonic jet of gas upstream into a uniform supersonic flow. The jet gas expands supersonically from the throat or exit to a high Mach Number, passes through a curved shock wave, and decelerates subsonically as it approaches an interface between the jet gas and the main flow. On the axis of symmetry the jet gas reaches a stagnation point at the interface. Results indicate that in relation to the supersonic stream the jet gas behaves like an axially symmetric blunt-nosed body bounded by the interface and that the main flow forms a detached bow wave, becomes subsonic in its central region, and accelerates to supersonic speed through a sonic line extending from the shoulder point of the jet interface. The study covers jets of air, helium, and sulphur hexafluoride with an indication of their stagnation temperature and stagnation pressure.

CONTRIBUTIONS ON THE MECHANICS OF LAMINAR-TURBULENT TRANSITION OF JET FLOW. U. Domm, H. Fabian, O. Wehrmann, and R. Wille. Tech. U. Berlin-Charlottenburg, Hermann Föttinger-Inst. Strömungstech. TR-56-9, Nov., 1955. 52 pp. 19 refs. ARDC-sponsored investigation of the growth and frequency of the small periodic disturbances near the nozzle, of the instability of the ring-vortex street, and of the mechanism of vortex fusion with the consequent decay of the coalesced vortices. Includes: discussion of the observed phenomena of the jet flow structure in the light of hydrodynamic theory, using results obtained by the dye filament method in water and by the hot-wire method in air; and description of axial symmetrical jet-flow experiments to give a first substantiation of the jet structure. Results of mean velocity profiles and measurements of frequency spectra indicate that: the geometry of the nozzle governs the flow in the first downstream region of the jet; a subsequently discovered periodic fluctuations pattern can be interpreted as a ring vortex street, with the structure of this region characterized by a frequency law; and the theoretically established instability of the ring vortex system is revealed as a frequency decrease (interpreted as vortex fusion) in the hot-wire signal, and as a frequency increase (interpreted as the decay of coalesced vortices) further downstream, at the appearance of intermittency.

ON THE FLOW OF A COMPRESSIBLE FLUID THROUGH ORIFICES. D.A. Jobson. IME Proc., No. 37, 1955, pp. 767-772; Communications, pp. 773-776. Derivation of a theoretical expression for the contraction coefficient C, appropriate to an orifice when trasmitting a compressible fluid, either above or below the critical pressure ratio, provided that the corresponding value for incompressible flow Ci, is known. Consideration is limited to cases in which the effect of friction is small, gravity and heat may be neglected, and isentropic changes of state obey a law of the type $P/p^n$ = constant (where P is the back pressure and p is the density at contracted area) over the range investigated. The theory is based on the principle that where conditions may be assumed to be nearly uniform across some section, such as at the vena contracta or the throat, the principles of energy, momentum, and continuity may permit a simple determination of both the size of the jet and the conditions across it. The theory is divided into two parts: in the first the pressure ratio across the orifice is assumed to be greater than the critical

value, so that the flow is subsonic, and constant conditions are assumed across the vena contracta which the jet may be expected ultimately to form; in the second, constant conditions are assumed at the first throat, where sonic conditions are postulated, and choked flows are considered. The contraction coefficients for both cases are calculated quantitatively by neglecting compressibility effects in the approach area to the orifice.

STUDIO SUGLI EIETTORI CON CAMERA DI MISCELAMENTO A SEZIONE COSTANTE. Vasco Caini. L'Aerotecnica (Rome), Feb., 1956, pp. 20-23. In Italian. Investigation to determine the values for the fluid-dynamic variables at the end of the mixing space in the case of a constant cross-section mixing chamber. Includes plots of the solutions as functions of the parameters, curves of general validity for the entropy step in the shock compressions, and a discussion of results.

ANALYTICAL AND EXPERIMENTAL INVESTIGATIONS OF INCOMPRESSIBLE AND COMPRESSIBLE MIXING OF STREAMS AND JETS. T.P. Torda and H.S. Stillwell. USAF WADC TR 55-347, Mar., 1956. 250 pp. 26 refs. Description of methods and summary of results leading to the extension of previous theories by taking into account the boundary layers developing along the duct walls upstream of the mixing region, at the start of mixing, in order to obtain a closer correlation between theoretical and test data. Analytical procedure employs an energy equation in addition to the momentum and continuity equations to eliminate the need for restrictive assumptions about the nature of the mixing-zone boundaries, and to make possible the determination of these boundaries and of the velocity profile from the equations and from the boundary conditions by using the von Kármán integral equations to evaluate the overall behavior. Analytical results indicate that the mechanism of viscous dissipation is different in the upstream boundary layers and in the mixing region, with the effect of this contraction confined to a very short distance downstream of the separating wall. The nonslip conditions, which play an important role in the establishment and development of the boundary layers along the separating wall, disappear at the end of the wall. Along and downstream of the wall, fresh energy, which replenishes the dissipated energy in the boundary layer and in the mixing region, is entrained from the potential flow and the entrained mass from the same source accounts for the increase of the thicknesses of the boundary layers and the mixing region. The velocity distribution in the mixing region evens out owing to viscous dissipation as the process progresses and, for the case of symmetric mixing, when the velocity and density distributions of the potential flows are the same, the velocity distribution in the mixing region is uniform at infinity, while in the case of nonsymmetric mixing, the velocity distribution varies linearly.

PRÉCISION EXIGÉE DANS LA CONSTRUCTION DES TUYÈRES SUPERSONIQUES. J.J. Ginoux. Tech. et Sci. Aéronautiques, No. 1, 1956, pp. 19-28. In French. Determination of the precision necessary for the construction of supersonic nozzles, based on the accuracy of instruments and measurements on models. Assuming the accuracy of the order of 1%, the error on the local slope of the nozzle wall is inferior to 0.002 rad for Mach 1.7. For Mach 1.1 the error becomes of 0.0003 rad and 0.0008 rad for Mach 5.0. Measurement of local variations of the static pressure and of the inclination of speed according to the axis, or of Mach Numbers is obtained, in order to determine the corrections of the wall. Includes a brief survey of fundamentals of the method of characteristics and an evaluation of the precision required for the construction of triangular-section supersonic nozzles.

## Stability & Control

APPLICATIONS OF MATRIX OPERATORS TO THE KINEMATICS OF AIRPLANE MOTION. M.J. Abzug. J. Aero. Sci., July, 1956, pp. 679-684. Development of kinematic relationships includes (1) the direct and inverse relationships between angular velocities and orientation angle rates, (2) the projections on earth axes of the small-disturbance motions calculated by classical airplane dynamic stability theory, (3) azimuth and elevation angles of a target on tracking airplane axes, (4) relationships between the orientation angles of NACA stability axes and arbitrarily aligned airplane body axes, and (5) the indications of free gyros (gimbal angles). The described method involves three successive applications to the yaw, pitch, and roll orientation angles of an airplane of the principle that the effects of a finite rotation of a reference frame on the projections of a vector on that frame may be represented by an orthogonal matrix, in order to yield the general matrix of transformation which is then applied to the problem of projecting from earth to airplane axes and vice-versa. The solution to this problem is used to derive (1). Derivation (2) is evolved from derivation (1) and the matrix transformation is used to yield derivations (3) and (4). Derivation (5) is obtained by equating the matrix of transformation to gyro matrices formed by consideration of successive finite rotations about the spin, inner gimbal, and outer gimbal axes. Results of the variations of inner and outer gimbal angles with airplane orientation angles for two typical gyros show that large discrepancies in indicated orientation angles and possible ambiguous readings exist for large values of bank and pitch angles.

FULL SCALE SPINNING TESTS ON THE PERCIVAL PROVOST MK. 1 INCLUDING THE INVERTED SPIN. T.H. Kerr. Gt. Brit., ARC CP 240, 1956. 32 pp. BIS, New York. $0.81. Results of tests showing that the normal spin has the characteristics of the smooth and oscillatory types depending upon the control configurations used. During the oscillatory spin the rising wing tip stalls and unstalls during each turn of the spin and can be smoothed by applying either anti-spin aileron or down elevator. The inverted spin is entered from an inverted glide and is a smooth spin at 45° incidence with rapid and satisfactory recovery.

STATIC LONGITUDINAL AND LATERAL STABILITY CHARACTERISTICS AT LOW SPEED OF UNSWEPT-MIDWING MODELS HAVING WINGS WITH AN ASPECT RATIO OF 2, 4, OR 6. Walter D. Wolhart and D. F. Thomas, Jr. US, NACA TN 3649, May, 1956. 41 pp. 12 refs. Results of an investigation in the Langley stability tunnel to determine the effects of various components and combinations of components on static longitudinal and lateral stability characteristics at low speed of unswept-midwing models having wings with an aspect ratio of 2, 4, or 6 through an angle-of-attack range from -4° to 32°. Included are the effects of large angles of sideslip at several angles of attack for some of the components and combinations. Results show that at low and moderate angles of attack, decreasing wing aspect ratio decreases the tail contribution to longitudinal stability. Near the angle of maximum lift for the configuration of the wing alone, a pronounced increase in longitudinal stability for all configurations involving the wing for all wing aspect ratios is found. For the complete model, changes in aspect ratio have little effect on the tail contribution to directional stability throughout the angle-of-attack range.

LOW-SPEED WIND-TUNNEL TESTS ON A MODEL OF A JET TAILLESS AIRCRAFT. J. Trouncer and G. F. Moss. Gt. Brit., ARC R&M 2843, 1956. 36 pp. BIS, New York. $1.71. Results of longitudinal and lateral stability tests given as coefficients of lift, drag, and pitching. Includes effects of split flaps, trimming flaps, dive-recovery flaps, and four types of anti-tip-stalling devices covering slats, nose flaps, double split flaps, and letter-box slats. Further includes ground effects in landing conditions

## Wings & Airfoils

AEROFOIL DESIGN IN TWO-DIMENSIONAL SUBSONIC COMPRESSIBLE FLOW. L. C. Woods. Gt. Brit., ARC R&M 2845, 1955. 54 pp. BIS, New York. $2.52. Derivation of design equations by extending the Lighthill method to the case of subsonic compressible flow. The Lighthill equations are shown to be a special case of general equations for airfoil design. Velocity distribution is defined numerically, and the nose radius is controlled by closure conditions for the airfoil. Compressible flow theory is based on the Kármán-Tsien approximation for calculating flow about a given airfoil. A method for estimating the effect of a modification to the designed airfoil shape on the velocity distribution is given, and five different airfoils are calculated for various conditions.

THEORETISCHE UND EXPERIMENTELLE UNTERSUCHUNGEN AN SCHIEBENDEN FLÜGELN, INSBESONDERE AN PFEIL- UND DELTAFLÜGELN. K. H. Gronau. Braunschweig, Deutsche Forschungsanstalt Luftfahrt, Inst. Aerodynamik, Bericht 55/9, Dec. 20, 1955. 122 pp. 25 refs. In German. Development of a practical method for the calculation of lift distribution on swept wings of a given shape in incompressible flow. The method is based on an extension of the Truckenbrodt lifting-line theory and used for the calculation of the stability values of a series of rectangular, sweptback, and delta wings. In order to obtain a comparison between theory and experiment, large systematic six-component measurements are taken. The comparison shows that the measured stability values are in good agreement with theoretically calculated values.

UNTERSUCHUNGEN ÜBER DEN ABWIND HINTER DELTAFLÜGELN BEI INKOMPRESSIBLER STRÖMUNG. K. Gersten. Braunschweig, Deutsche Forschungsanstalt Luftfahrt, Inst. Aerodynamik, Bericht 55/22, Jan., 1956. 32 pp. 14 refs. In German. Theoretical and experimental investigation of the downwash behind delta wings in incompressible flow, measured by a tuft grid method. Numerical values for the induced velocity are given from photographic recordings of the grids. Theoretical determination of the downwash is obtained from the calculation of the lift distribution using the Truckenbrodt airfoil theory. Results indicate that the calculation for points located near the edge of the wing can be simplified by applying an approximation formula. Theoretical results are compared with measurements. Includes an analysis of the tuft grid operation recordings which illustrate the flow occurrence behind delta and swept wings by a change of four parameters: aspect ratio, angle of attack, angle of sideslip, and span of the airfoil.

ON THE USE OF INTERFERING FLOW FIELDS FOR THE REDUCTION OF DRAG AT SUPERSONIC SPEEDS. Antonio Ferri and J. H. Clarke. Polytech. Inst. Bklyn. Dept. Aero. Eng. & Appl. Mech., PIBAL Rep. 304, Mar., 1956. 71 pp. 17 refs. OSR-supported study including a general outline of possibilities for favorable wave interference between supersonic aircraft components. The interference between a three-dimensional wing with swept leading edges and a small reflecting surface in biplane arrangement is discussed in terms of the linearized flow theory. Relationships are developed to facilitate the determination of the interference drag of a large class of three-dimensional configurations neglecting the calculations of the flow field. Application of the method to several biplane configurations of practical interest is illustrated. Results show that the drag of the wing can be greatly reduced or that the volume near the wing root section can be considerably increased without penalty in drag. The discussion of the three-dimensional biplane points out some practical applications, particularly in the higher Mach Number range.

COMPARISON BETWEEN EXPERIMENTAL AND PREDICTED DOWNWASH AT A MACH NUMBER OF 0.25 BEHIND A WING-BODY COMBINATION HAVING A TRIANGULAR WING OF ASPECT RATIO 2.0. N. E. Sorensen and E. J. Hopkins. US, NACA TN 3720, May, 1956. 29 pp. Study to evaluate a method for predicting the downwash in a transverse plane behind a wing-body combination throughout an angle-of-attack range from 0° to 20°. The predicted downwash is calculated by a numerical method in which an array of discrete vortices is allowed to roll up. The wing vortices are assumed to emanate from the

trailing edge of the wing with their positions and strengths determined from the measured spanwise distribution of load.

## AEROELASTICITY

AEROELASTIC PROBLEMS OF LOW ASPECT RATIO WINGS. IV - APPLICATION OF THE STRUCTURAL AND AERODYNAMIC MATRICES TO THE SOLUTION OF THE FLUTTER PROBLEM. J. Leyds. Aircraft Eng., May, 1956, pp. 166, 167. Description of digital and analog computational methods and theoretical consideration of the energies to be substituted for variables in the Lagrange equations. The wing is divided into a great number of sections by a process similar to that of finding the aerodynamic forces. The mass of each section is assumed to be evenly distributed over the section.

FLUTTER CALCULATION OF WING WITH AN ELASTICALLY SUPPORTED CONCENTRATED WEIGHT. Kichiji Nishino. J. Japan Soc. Aero. Eng., Apr., 1956, pp. 1-7. Investigation of the effect of a spring-mounted, concentrated mass on the bend-torsion flutter characteristics of a two-dimensional airfoil. Calculations of the relations of the flutter coefficient ($V_F$) and frequency-to-spring ratio for various chordwise mounting positions. Results indicate two possible types of flutter, type A, in which the phase difference between wing translationary and concentrated weight motions is about 180°, and type B, where the two phases are approximately the same. In a chordwise forward support type A flutter is liable to occur for softer springing, and type B flutter for harder springing. In the rearward chord position type B flutter occurs for all spring stiffnesses. A reduction in flutter velocity is possible if the mass is mounted near the front neutral point (25% of the chord), using a spring stiffness calculated from developed formulas.

WIND-TUNNEL FLUTTER TESTS ON A MODEL DELTA WING UNDER FIXED AND FREE ROOT CONDITIONS. D.R. Gaukroger, E.W. Chapple, and A. Milln. Gt. Brit., ARC R&M 2826, 1955. 10 pp. BIS, New York. $0.54. Results of low-speed tests on a half-span model delta wing with fixed-root conditions and with body freedoms in pitch and vertical translation. Critical flutter speed and frequency are given for variations in wing inertia axis, wing and fuselage center of gravity, fuselage pitching moment of inertia, and fuselage mass. Tests show that under root-free conditions, body freedom flutter occurs at low values of fuselage pitching moment of inertia, but at higher values the flutter is similar to that obtained with root-fixed conditions.

THE COMPRESSIBLE FLOW PAST AN OSCILLATING AIRFOIL IN A WIND TUNNEL. J.W. Miles. J. Aero. Sci., July, 1956, pp. 671-678. 14 refs. Analysis of the disturbance produced by an oscillating airfoil in a two-dimensional supersonic wind tunnel. The solution is presented either as an expansion in the fields of the image or in the natural modes or guided waves of the tunnel. The image field method is preferable at supersonic speed, but the guided wave approach is superior in the presence of very strong airfoil tunnel interference. The two methods of viewing the solution are unified through a Laplace transformation for the supersonic problem or a Fourier expansion for the subsonic problem. The supersonic results are applied to the calculation of the longitudinal stability derivatives associated with a low frequency pitching oscillation.

NUMERICAL INTEGRATION METHODS FOR SUPERSONIC WINGS IN STEADY AND OSCILLATORY MOTION. B. Etkin. UTIA Rep. 36, Nov., 1955. 53 pp. 14 refs. Extension and review of the Etkin and Woodward results for the case of thin lifting wings in steady flow, with application of the steady flow equations to an untwisted wing having a symmetrical section at zero incidence, and derivation of summation formulas suitable for computation by digital computers. Includes formulas for very low frequencies (in the stability range), which correspond to quasi-steady flow or the zero-order oscillatory theory, and for which the formulas are identical with those governing the steady flow and Evvard's method for subsonic leading edges is valid. A law to moderate frequencies, in which squares and higher powers of the reduced frequency are neglected, and for which Evvard's method for subsonic edges is still valid and the formulas relatively simple is also included. Analytic results indicate that, for all frequencies, there is a region near the apex of the wing whose size varies inversely with reduced frequency, and in which the quasi-steady or zero-order analysis may be applied.

THEORETICAL AERODYNAMIC PROPERTIES OF VANISHING ASPECT RATIO HARMONICALLY OSCILLATING RIGID AIRFOILS IN A COMPRESSIBLE MEDIUM. Bernard Mazelsky. J. Aero. Sci., July, 1956, pp. 639-652. Extension of the Garrick results to the compressible case, with the solutions for the velocity potential determined from the two-dimensional wave equation instead of the Laplace equation. Numerical results are obtained for the complete reduced frequency range, used for evaluating the expressions of lift, pitching, and rolling moment for rectangular and triangular plan forms, and then compared with those obtained by Merbt and Landahl. Use is made of available closed-form solutions for the required boundary layer, in terms of Mathieu functions, and of tabulations for all the required functions for determining the aerodynamic properties for the complete range of the parameter reduced frequency times Mach Number. The significant variable introduced in defining the oscillatory coefficients when the flow is compressible is the single entity, $k_0M$, and Mach Number variations enter only through this quantity. Comparisons of the oscillatory coefficients based on compressible and incompressible flow indicate that, for the range of reduced frequencies applicable to flutter, the effects of compressibility can be considered negligible.

A TECHNIQUE FOR THE MEASUREMENT OF PRESSURE DISTRIBUTION ON OSCILLATING AEROFOILS, WITH RESULTS FOR A RECTANGULAR WING OF ASPECT RATIO 3.3. W.G. Molyneux

and F. Ruddlesden. Gt. Brit., ARC CP 233, 1956. 24 pp. BIS, New York. $0.63. Development of a pressure transducer of the resistance strain gage type whose output is measured directly by a sensitive galvanometer. Values for aerodynamic derivatives are obtained from the integrated pressure distributions and are compared with those derived from overall force measurements and with theoretical values.

AN AEROELASTIC PARAMETER FOR ESTIMATION OF THE EFFECTS OF FLEXIBILITY ON THE LATERAL STABILITY AND CONTROL OF AIRCRAFT. William P. Rodden. J. Aero. Sci., July, 1956, pp. 660-662. Derivation of an aeroelastic parameter introduced in a quasi-steady analysis which separates the effects of Mach Number from those of altitude on the lateral motion of a flexible wing. The effects of flexibility are included by modifying the one-degree-of-freedom rolling moment equation. The determination of aileron reversal speed and applications to preliminary design are discussed. The three-degrees-of-freedom motion can be analyzed if additional aeroelastic effects on the wing dihedral, vertical stabilizer, and fuselage are included.

INFLUENCE OF LARGE AMPLITUDES ON FLEXURAL MOTIONS OF ELASTIC PLATES. George Herrmann. US, NACA TN 3578, May, 1956. 45 pp. 21 refs. Derivation of a set of plate equations of motion for an isotropic material obeying linear Hooke's law, based on fundamental equations of the general three-dimensional nonlinear theory of elasticity for the case of small elongations and shears, but moderately large rotations. Analysis of the resulting nonlinear plate theory of motion valid for large deflections, in terms of the three-dimensional and other nonlinear plate theories, in particular the von Kármán static plate theory. The nonlinear equations are solved for the case of propagation of straight-crested waves, and the wave velocities are computed for various values of the parameters involved, in order to investigate the influence of large rotations in a dynamic problem. Also includes a derivation of a variant of plate equations which permits tracing back the origin of certain terms appearing in other nonlinear plate theories, clarifying the underlying assumptions of these theories.

THE FLEXURE-TORSION FLUTTER OF CAMBERED AEROFOILS IN CASCADE. A.H. Craven and I. Davidson. Coll. of Aeronautics, Cranfield, Rep. 95, Dec., 1955. 36 pp. Results of a series of tests on the flexure-torsion flutter of cascade airfoils of $30^{\circ}$ and $45^{\circ}$ camber, covering stagger angles between $-30^{\circ}$ and $+30^{\circ}$, and gap chord ratios up to 1.5 at a Reynolds Number of $1 \times 10^5$ based on airfoil chord. The critical flutter speeds and frequencies in cascade are expressed as ratios of the values for the airfoil in an isolated condition. Results: camber increases the critical flutter speed ratio and decreases the critical frequency ratio for any given value of gap chord ratio; stagger has an appreciable effect on the flutter characteristics of a cascade of cambered airfoils; negative stagger angles further increase the critical flutter speed ratio and decrease the critical frequency ratio so that the critical flutter speed of a cascade of cambered airfoils can be greater and the critical flutter frequency much lower than that of an isolated airfoil, while positive stagger angles have an opposite effect; for gap chord ratios greater than 1/4 and stagger angles less than $+20^{\circ}$, the flutter frequency ratio is less than unity, in distinction to the results for symmetrical airfoils; and the reduction in tip clearance reduces considerably the critical flutter speed ratio but has little effect on the critical flutter frequency ratio.

VIBRATION AND STABILITY PROBLEMS OF BEAMS TREATED BY MATRICES. K. Marguerre. J. Math. & Phys., Apr., 1956, pp. 28-43. OSR-sponsored investigation of the matrix method for solving the differential equation of a vibrating beam and for the related problem of the vibrating column. Exact calculations are shown for the eigenvalues of vibrating and buckling beams, taking into account concentrated supports, concentrated masses, and pin connections. These discontinuties are overcome by introducing an associated $\Delta$ - matrix, for which simple rules of calculation can be found.

TEORIA E APPLICAZIONE DEI MODELLI STRUTTURALI NELLE COSTRUZIONI AERONAUTICHE. Giuseppe Gabrielli. ZFW, May-June, 1956, pp. 198-202. 22 refs. In Italian. Evaluation of a method for the transference of results of elasticity or failure tests from models to actual aircraft. Using the principal factors to determine the loads on aeronautical structures, the law of structural similarity is derived. Herbert Wagner's diagram permits the evaluation of the behavior of structures with regard to local yields having different natures and origins, and also permits an evaluation of the form of the section and of suitable materials. In this diagram the index of structural load appears on the abscissa and represents a constant for every given structure. It also expresses the law of structural similarity applied to the proportionality limit.

## AIRPLANE DESIGN

ECCENTRIC LANDING WITH HEAVY MASSES AT THE WING TIPS. Alexander Grzedzielski. J. Aero. Sci., July, 1956, pp. 653-659, 678. 10 refs. Theoretical analysis assuming a conventional aircraft whose landing gears make contact with the ground one after the other, the second contact taking place before the shock absorbing process of the first gear is completed. Results indicate that: the effective mass acting on (or the drop mass of) one shock absorbing unit, the magnitude of which depends on the ratio of the radius of gyration of the aircraft in roll to the undercarriage tread, on the initial roll angle, and on the roll velocity at the moment of first contact, may be larger than one half of the total mass of the aircraft; since the time span between two impacts and the magnitude of each impact depend on the initial roll angle and roll velocity, both of which can have any values within certain statistical

limits, an asymmetric wing vibration can be generated and have larger effects on wing stresses than the symmetric vibration due to the symmetric landing; parameters defining the landing gear strength, in general, include sinking velocity, roll angle, and roll velocity; and, from available information concerning shock absorber characteristics, it appears that for large tip masses the shock absorption capacity of the gear should be checked in two cases at least a) in the case corresponding to symmetric landing shock (small drop mass and large sinking velocity) and b) in the case of eccentric landing shock (large drop mass and small sinking velocity). The outlined method can provide a basis for a compromise between the restrictions imposed on landing conditions and the improvement of the design offered by tip masses.

## ELECTRONICS

EXTERIOR ELECTROMAGNETIC BOUNDARY VALUE PROBLEMS FOR SPHERES AND CONES. L.L. Bailin and Samuel Silver. IRE Trans., AP Ser., Jan., 1956, pp. 5-16. 13 refs. USAF-sponsored theoretical analysis, using a technique similar to that for the theory of slots in waveguide walls, to determine a harmonic time-varying electromagnetic field where the electric vector assumes prescribed values for its tangential components over given spherical or conical boundaries and which has proper radiation characteristics at infinity. Includes the formal solutions for arbitrarily shaped apertures on cones applied to several types of delta slots in order to illustrate the applicability and limitations of the method. Details of the technique are discussed in connection with the infinite cone. The described technique involves the establishment, by the use of the Lorentz reciprocity theorem, of a Green function which represents the electric and magnetic fields of a point generator (infinitesimal dipole) applied at an arbitrary position on the conducting surface where the fields satisfy homogeneous boundary conditions. The total fields are obtained for an arbitrary source by superposition. The results apply directly to the theory of radiating apertures in a perfectly conducting spherical wall or cone, since the tangential components of the electric vector are different from zero only in the area of the aperture, where they are presumed to be known. Results also apply to scattering by conducting spheres and cones, since the tangential electrical field components over the boundary surfaces are the negative of those of the incident field.

### Antennas

ANALYSIS OF A TERMINATED-WAVEGUIDE SLOT ANTENNA BY AN EQUIVALENT CIRCUIT METHOD. L.B. Felsen. IRE Trans., AP Ser., Jan., 1956, pp. 16-26. USAF-sponsored consideration of symmetric rectangular E and H plane slots radiating from the broad or narrow face of a rectangular waveguide. Description of an approximation procedure for large slots, and summary in stepwise form of the complete method for computing the patterns of E and H plane slots. The method involves the representation of the coupling properties of the slot by a lossless four terminal-pair equivalent network whose parameters, determined either theoretically from a variational calculation or from direct measurement in the feeding guide, may be expressed at suitable reference planes approximately in terms of those of the lossy two terminal-pair equivalent circuit for the radiating slot, when considered as a dissipative element in the rectangular waveguide. The pattern of the slot with a given termination is computed from a simple network calculation and subsequent model synthesis, when the slot equivalent circuit parameters are known.

OPTICAL FRESNEL-ZONE GAIN OF A RECTANGULAR APERTURE. Charles Polk. IRE Trans., AP Ser., Jan., 1956, pp. 65-69. ARDC-supported study with derivation of an equation to extend the scalar diffraction theory for an illuminated circular aperture to an illuminated rectangular aperture having zero phase-error. Results indicate that the Fresnel gain correction factor for such a rectangular aperture differs significantly from the corresponding simple $(\sin x/x)^2$ factor of a circular aperture even if the departure is a square and that this is particularly true at distances where the $(\sin x/x)^2$ factor would predict zero gain. The results are applicable to antenna gain measurements at distances, R, shorter than indicated by the usual far-field limit $R \geq 2L^2/\lambda$, where L is the largest linear dimension of the aperture and $\lambda$ is the wavelength; and in certain radio interference problems where the field intensity in the Fresnel region is of interest.

### Wave Propagation

SOME RELATIONSHIPS BETWEEN TOTAL SCATTERED POWER AND THE SCATTERED FIELD IN THE SHADOW ZONE. J.T. Bolljahn and W.S. Lucke. IRE Trans., AP Ser., Jan., 1956, pp. 69-71. USAF-sponsored derivation of equations which relate the far-zone scattered field, as measured in the scattered zone of an electromagnetic scatterer, to the total energy scattered and absorbed by the scatterer. In the case of a perfectly conducting scatterer the energy stored in fields about the scatterer is also related to the far-zone scattered field in the zone shadow. Results of the analysis indicate that the sum of the scattered power and absorbed power due to an arbitrary scatterer in a plane wave and both the scattered power and the mean stored energy in the scattered field of a perfectly conducting scatterer may be determined by a measurement of the scattered field amplitude and phase at a single point in the shadow zone.

## INSTRUMENTS

### Automatic Control

LOADING CONDITIONS FOLLOWING AN AUTOMATIC PILOT FAILURE. I - RUDDER CHANNEL. II - ELEVATOR CHANNEL. D.R. Puttock. Gt. Brit., ARC CP 242, CP 243, 1956. 35 pp., 50 pp. BIS, New York. $0.90, $1.35. Investigation based on the response theory of rudder and elevator movement when a rudder failure of the automatic pilot occurs. Analysis of the response to determine the

movements producing the critical loads and to obtain markable formulas and charts suitable for routine estimation of these loads. Includes establishment of an elevator time and a rudder time history and derivation of the response of an aircraft to established elevator and rudder movement.

### Flow Measuring Devices

DEVELOPMENT OF AN AIR MASS-FLOW RATE METER. W.J.G. Cox. Gt. Brit., ARC CP 230, 1956. 47 pp. BIS, New York. $0.81. Description of an apparatus which is essentially an analog computer and gives a two-sweep pointer direct presentation, independent of pressure, temperature, and velocity changes within the range of the instrument. Includes specifications and performance figures for the individual transducer elements and the complete instrument, error estimations, and discussion of servo stability. Pointers of the instrument are driven by a servo system, error-actuated from a computing bridge network, and a secondary feedback is used to maintain stability with a saturated angular output rate of 33° per sec. The output being a shaft rotation, the system could be modified for remote indication on several different dial scales, each calibrated for a particular air duct and an extension of the indicating scale to three or more sweeps would give further refinement of indication and accuracy. The device is applicable to direct indication of fuel-to-air mass flow ratios.

### Pressure Measuring Devices

MEASUREMENT OF PRESSURE DISTRIBUTION ON OSCILLATING WINGS IN SUPERSONIC FLOW. I - EXPERIMENTAL METHODS. Erik Mollø-Christensen and S. Dean Lewis. MIT ASRL TR 57-1, Dec. 31, 1955. 45 pp. Development of a method for measuring pressure on oscillating wings, using a thin pressure-sensitive probe traversing the wing in a chordwise direction, but not in contact with it. Pressures and wing displacement were recorded on magnetic tape during the run, and the signals were analyzed by playing the tape through a wave-form analyzer and a phase meter.

A REMOTELY-CONTROLLED TRAVERSING YAWMETER FOR BOUNDARY-LAYER EXPLORATION. D.W. Bryer. J. Sci. Instr., May, 1956, pp. 173-175. Design details of a pressure-probing apparatus, its safety devices, and its system, in order to relate the traverse to an accurate datum position. The Conrad yawmeter technique for measurements of velocity in the attached three-dimensional boundary layer is shown to have an overall accuracy of $\pm$ 1.6%, when the angle of pitch of the yawmeter remains within $\pm$ 6° of the local mean-flow direction. The technique, incorporating revolution counters, performs rapidly, giving a direct indication of position when the yawmeter is mounted on a micrometer mechanism controlled through flexible motors. It is further shown that, in regions of detached flow, such as occur in the wake of a wing at high incidence, measurements of velocity and flow direction are obtained with an instrument which can be alined to the local mean-flow direction. Additional apparatus to include the remote adjustment of pitch is being developed for this purpose.

### Stress & Strain Measuring Devices

A HIGHLY SENSITIVE GAUGE FOR THE MEASUREMENT OF LARGE STRAINS. A.G. Boyer and J.P.O. Silberstein. Australia, ARL S&M Note 221, Oct., 1955. 10 pp. Development of an electrical strain gage in the form of an arch with two bonded gages attached to the top of the arch. This device can measure strains of $\pm$ 7.5%, is sensitive to strain differences of $10^{-7}$, can measure strains to $\pm 10^{-5}$ over a range of $\pm$ 5% without resetting, has a negligible drift over intervals of many hours and a maximum hysteresis of less than 0.5% of the total operating range.

## MATERIALS

### Metals & Alloys, Nonferrous

BLISTERING IN ALUMINIUM ALLOYS. I.J. Polmear and F.E. Beissel. Australia, ARL Rep. Met. 14, Oct., 1955. 54 pp. 38 refs. Investigation which indicates that blistering occurs if the material contains dissolved hydrogen gas and internal cavities into which the gas may diffuse. Reaction of moisture with molten and solid aluminum provides the main source of hydrogen. Methods of reducing gas content at all stages of manufacture are considered from the aspects of eliminating atmospheric moisture, inhibiting the reaction by stabilizing the aluminum oxide film, and efficient degassing of molten alloys.

JOINING TITANIUM; FUSION-WELDING, BRAZING AND SOLDERING TECHNIQUES FOR MISSILE DESIGN. Aircraft Prod., June, 1956, pp. 242-246. Application of the welding processes to titanium. Discussion includes weldability as compared to other metals, tooling for fusion welding, description of a special fitting for welding joints of various types and research to simplify the welding process. Conclusion shows that the strength-weight properties of titanium-welded joints are superior to those of other metals.

## MATHEMATICS

ASYMPTOTIC SOLUTION OF SOME DIFFRACTION PROBLEMS. J.B. Keller, R.M. Lewis, and B.D. Seckler. Commun. on Pure & Appl. Math., May, 1956, pp. 207-265. 25 refs. Application of the method by which the asymptotic expansion may be determined with respect to frequency for periodic solutions of electromagnetic, acoustic, and other linear wave problems. Mathematical approach covers the determination of the asymptotic expansion of the solution of a boundary-value problem for an elliptic equation. Includes a review of other fields of application.

ON THE INTEGRATION METHOD OF BERGMAN AND LEROUX. J.R. Diaz and G.S.S. Ludford. Maryland U., Inst. Fluid Dynamics & Appl.

Math. TN BN-69 (AFOSR TN-56-140), May, 1956. 9 pp. OSR-OOR-sponsored analysis of the correspondence between the representations of solutions of the canonical-form linear hyperbolic differential equations in two independent variables given by Bergman and Le Roux. Derivation of a second correspondence in order to avoid the difficulty arising from the fact that in the first correspondence to the regular kernel functions in the sense of Le Roux there may correspond singular kernel functions in the sense of Bergman.

LES APPLICATIONS SCIENTIFIQUES DE LA NOTION DE RÉGULARITÉ. Pierre Vernotte. France, Min. de l'Air PST 307, 1956. 84 pp. In French. Detailed analysis of the regularity concept in mathematical and physical research, with specifications of such factors as the successive differences, transformations, interpolation, and interpretation of experimental curves.

ADDITION THEOREMS FOR THE FUNCTIONS OF THE PARABOLOID OF REVOLUTION. Harry Hochstadt. NYU Inst. Math. Sci., Div. Electromagn. Res., Res. Rep. BR-18 (AFOSR TN 56-190), May, 1956. 22 pp. Development of expansions or additional theorems for the functions of the paraboloid of revolution with reference to a new coordinate system which differs from the original by a translation or a rotation.

I - SOME CONTRIBUTIONS TO THE PROBLEM OF THE EXTENSION OF POSITIVE DEFINITE FUNCTIONS. II - ON INFINITELY DIFFERENTIABLE POSITIVE DEFINITE FUNCTIONS. Allen Devinatz. U. Conn. Project Rep. OSR TN-55-421, Oct., 1955. 45 pp. 20 refs. Study of the possibility of extending Bochner's theorem of harmonic analysis to the class of Euclidean spaces considered as topological groups, and to a defined and infinite differentiable function f(x) which satisfies three conditions (including a determined Hamburger moment sequence) in order to prove that f(x) can be extended to be a positive definite function.

EXPONENTIAL SOLUTIONS OF SECOND-ORDER SYSTEMS. Abe Shenitzer. NYU Inst. Math. Sci., Div. Electromagn. Res., Res. Rep. BR-17 (AFOSR TN-56-172), Apr., 1956. 11 pp. Study indicating for a 2 x 2 matrix depending analytically on a parameter t, the vanishing of all Lie functions of an order exceeding a given, but arbitrarily large number implies the vanishing of the second-order Lie functional. Includes generalization of some Hellman relations for the coefficients of a matrix which is analytic in t and has certain vanishing Lie functionals.

## METEOROLOGY

STANDARD ATMOSPHERE - TABLES AND DATA FOR ALTITUDES TO 65,800 FEET. International Civil Aviation Organization, Montreal, and Langley Aero. Lab., Langley Field. US, NACA Rep. 1235, 1955. 114 pp. Supt. of Doc., Wash. $0.75. Manual containing a detailed specification as defined in Annex 8 to the Convention on International Civil Aviation, with basic data mainly in the fundamental c.g.s. system of units, and with derivation of expressions for the relationship between meteorological and physical quantities to provide a reference basis for certain elements in the free air up to 65,617 feet.

## MISSILES

MISSILE GUIDANCE BY THREE-DIMENSIONAL PROPORTIONAL NAVIGATION. F.P. Adler. J. Appl. Phys., May, 1956, pp. 500-507. Analysis extending planar proportional navigation system to three dimensions, based upon a criterion for optimum navigation to the line-of-sight motion. The system is formulated in terms of geodesic and normal curvatures of the missile path on the surface generated by the line of sight and, by suitable choice of a reference coordinate system, the missile-target kinematic relationships are linearized, assuming relatively small deviations of the missile from a collision course. The geometry feedback equations and the equations of guidance are combined to give the missile trajectory in terms of two independent linear differential equations of identical form and of one order higher than the missile transfer function. Trajectory is shown to depend on an "effective navigation constant" proportional to the missile navigation constant and the ratio of missile speed to closing speed.

SULLE POSSIBILITÀ DEL MISSILE IN VOLO VERTICALE; DEDUZIONE DEI PARAMETRI FONDAMENTALI DI PROGETTO DEL MISSILE DALLE CARATTERISTICHE DEL SUO IMPIEGO. Corrado Casci. L'Aerotecnica (Rome), Feb., 1956, pp. 27-36. In Italian. Theoretical analysis to determine the fundamental parameters of missile design from the missile flight characteristics, such as altitudes attained, relative velocity along the trajectory, and duration of climb. Results are presented in the form of diagrams which can be used in the calculation of these parameters for design purposes. Results indicate that the fundamental parameters to be considered are propellant consumption, mass ratio, burning time, and lightness. The highest altitudes can be attained only by missiles having a high mass ratio, but it is unlikely that construction limitations will permit a mass ratio higher than 0.75 in the near future. The flight time of the rocket in operation should range from 60 to 70, this being the optimum range for consumption. It is shown that, since the parameters vary with the variation of missile operational characteristics, they may be assumed to conform to the purposes for which the missile is to be used.

## NUCLEAR ENERGY

ÉTUDE DE LA DIFFUSION DANS LES GELS À L'AIDE DES ISOTOPES RADIOACTIFS. Suzanne Cordier. France, Min. de l'Air NT 57, 1956. 71 pp. 50 refs. In French. Study of the fundamental concepts of diffusivity. Application of radioactive isotopes for the measurement of gel diffusion coef-

ficients in homogeneous media. Includes a study of the variation of diffusion coefficients as function of such variables as the concentration of the diffusive electrolyte, gel concentration, and concentration of foreign salts.

## PHOTOGRAPHY

EVALUATION OF THE CZR-1 FIXED CAMERA SYSTEM. R.J. Nichol, Ernest Stern, and S.A. Chamer. USAF MTC TN-56-27, Apr., 1956. 43 pp. Description of the CZR-1 camera used to obtain photographic recordings applicable to problems involving position velocity, acceleration of missiles at the time of launching and recovery, and in the initial stages of trajectory. Test procedures and methods for reducing and analyzing the gathered data are described. Results indicate that the standard deviation of the combined random error and random bias is estimated as 52 sec. for azimuth and 26 sec. for elevation. The presence of an appreciable fixed bias is indicated in the system with the average bias over all observations amounting to 39 sec. in azimuth and -5 sec. in elevation.

## PHYSICS

FLUCTUATIONS IN OSCILLATING SYSTEMS OF THE THOMSON TYPE. I, II. S.M. Rytov. Soviet Physics - JETP (Zhurnal Experimentalnoi i Teoreticheskoi Fisixi, Sept., 1955), Mar., 1956, pp. 217-235. Translation. Development of a theory based on considerations of a system with one degree of freedom, and using symbolic differential equations containing random functions which describe the fluctuations, in conjunction with methods of correlation theory. Applied to an isolated system, the physical example of a weakly self-excited vacuum-tube oscillator, a non-isolated system with one degree of freedom, and a system with two degrees of freedom. Includes consideration of the influence of the method of frequency stabilization on fluctuations of amplitude and phase, and of the way in which thermal fluctuations are taken into account.

## POWER PLANTS

### Jet & Turbine

PERFORMANCE CRITERIA OF GAS-TURBINE COMBUSTION CHAMBERS; A METHOD OF COMPARISON AND SELECTION FOR THE DESIGNER. II. D.B. Spalding. Aircraft Eng., May, 1956, pp. 168-172. A method of comparing combustion chamber designs with each other by plotting the values of incompatible pairs of criteria is presented. The plots can be used for design purposes, taking into account pressure drop, large combustion chamber volume, and stability range. Certain characteristics of practical gas-turbine combustion chambers are analyzed in terms of an idealized two-stream model. Includes a comparison with Bragg and Holliday results.

DEVELOPMENT OF AN AIR INJECTOR. F. Cheers. Canada, NRC Div. Mech. Eng. Rep. MT-31, Mar., 1956. 18 pp. Discussion of problems in designing an air injector to provide increased velocities for testing large combustors. Initial tests with the mixing pipe exhausting through a short diffuser to the atmosphere show that the design mass-flow could be attained, but that the noise level is high, the velocity distribution unsteady, and the mixing at the end of the pipe is poor. A relatively high drag test rig fitted at the end of the mixing zone provides a high pressure drop to even out the velocity distribution, but the noise level remains high.

### Reciprocating

THE AERODYNAMICS OF THE COOLING OF AIRCRAFT RECIPROCATING ENGINES. A.S. Hartshorn and L.F. Nicholson. Gt. Brit., ARC R&M 2498, 1956. 135 pp. 152 refs. BIS, New York. $7.20. Includes theory of flow in a heat exchanger duct, review of cooling drag of radiator installations, the cooling of air-cooled engines, design of non-annular and annular entries, exit flap design, static pressure at cooling duct exit, spoiling effect of radial engine gills on a wing, drag of a faired nacelle installed on a wing, spoiling effect of engine exhausts in front of a wing, exhaust-actuated cooling air ejectors, and the design of fans to assist cooling.

### Rocket

INSTABILITÉS DE LA COMBUSTION DANS LES MOTEURS FUSÉES; ÉTUDE EXPÉRIMENTALE. M. Barrère, A. Moutet, and P. Sarrat. France, ONERA Pub. 82, 1956. 66 pp. 39 refs. In French. Summary of experimental techniques used in the study of combustion instability. Includes description of measuring equipment and of propulsion units used in the experiment. Also includes a description of low frequency instabilities dependent on the ignition delay. The importance of several parameters of the rocket engine related to this phenomena is pointed out. Experimental results are in agreement with theoretical results if the same combustion-chamber pressure is maintained, but all other parameters can vary. The differences are noticed when different pressure values are used. The high frequency instabilities, influenced by the acoustics of the combustion chamber, are analyzed; the different parameters, particularly those related to the geometry of the chamber, are studied systematically; and the importance of the convergent and of the injection system is pointed out.

## ROTATING WING AIRCRAFT

MECHANICAL STABILITY OF A TWO-BLADED CANTILEVER HELICOPTER ROTOR. P.F. Leone. J. Aero. Sci., July, 1956, pp. 633-638. Theoretical investigation to generalize the Feingold solution for the case in which the blades are assumed inelastic and attached to the hub by means of vertical hinges. Analytical results for a configuration whose hub is mounted upon isotropic elastic supports in the horizontal plane and whose elastic blades employ fixed root attachments indicate that the Feingold solution remains applicable also to the general case

if the Coleman parameters $\Lambda_1$, $\Lambda_2$, and $\Lambda$, are appropriately defined by using the natural frequencies and modal shapes of the free uncoupled lag bending vibrations of the blades.

## SAFETY

GENERALIZED TRAJECTORY CURVES FOR BODIES MOVING IN AIR. R.J. Templin and M.M. Callan. Canada, NAE LR 159, Mar. 7, 1956. 12 pp. Construction of a chart applicable in aircraft accident investigations to reconstruct trajectories for large numbers of oddly shaped objects, and derived from the ratio of initial-to-terminal velocity and the trajectory angle. The chart permits the development with a drafting machine of trajectories with any given initial conditions, the ready transference of data to x, y coordinates for any terminal velocity, and the application of a given terminal velocity to objects. The ratio of the velocity along the trajectory to the terminal velocity is used as a variable to extend the usefulness of any developed trajectory. Includes several generalized plots as illustrative examples.

THE IN-FLIGHT COLLISION PROBLEMS. J.O. Brantley. Aero. Eng. Rev., July, 1956, pp. 45-53. 14 refs. Outline of some basic factors related to the air-borne collision avoidance problem, with an evaluation of self-sufficient preventative and warning equipment.

## SPACE TRAVEL

FLIGHT MECHANICS OF ASCENDING SATELLITE VEHICLES. F.M. Perkins. Jet Propulsion, May, 1956, pp. 352-358. Solution of the optimum vacuum stage thrust axis pitch program for a satellite using continuous thrust all the way from ground to orbit, with an explanation of trajectory optimization to minimize propellant consumption for a vehicle using a power-off coast up to the orbit, and of analog and digital computer techniques for trajectory calculations. Includes discussion of types of orbits and trajectories. Discussion covers auxiliary orbits and orbits of departure and arrival for astronautical expeditions, and the continuous and interrupted thrust types of trajectories. Results indicate the possibility of determining an approximate optimum design or region of practical designs to accomplish any particular mission from general performance studies and preliminary weight estimates.

CONTROL AND POWER SUPPLY PROBLEMS OF INSTRUMENTED SATELLITES. Ernst Stuhlinger. Jet Propulsion, May, 1956, pp. 364-368. Description of a method of using the earth's shadowing effect on the isotropic cosmic radiation to regulate the satellite's attitude in relation to the earth's center, and of several possible systems having a specific power production of 0.4 and 0.7 watts per pound of weight to produce about 100 watts of electric power each. These include: a silicon junction photoelectric generator to convert solar energy, with a sun-seeking device to keep it oriented toward the sun during the daytime; a pile of thermocouples, to make use of the same energy source, which are made out of ZnSb and constantan; and a pile of thermocouples to derive heat from a radioactive isotope, strontium 90, with a half-life of 20 years, and its product, yttrium 90. In the attitude control system, signals resulting from the counting rate of a number of Geiger counters, arranged in order to sense the location of the earth's shadow cone, control the flywheels, causing the satellite to rotate around its center of gravity. Results of the study indicate that: efficiency for each of the electric power conversion methods is approximately 5%; the efficiency of a steam-electric generator with heat derived from the sun, a radioactive isotope, or a small nuclear reactor may be as high as 10% to 15% for a power output of 20 kw, although at a power level of only 100 watts it would be considerably below 5%; but, with the improvement of semiconducting photoelectric cell efficiency, photoelectric generators energized solarly will probably prove superior to steam-electric generators even for large manned satellites, if the danger of radiation can be successfully overcome. Includes a brief discussion of minimum instrumentation requirements, and those for more accurate and intricate observations.

LIFETIMES OF SATELLITES IN NEAR-CIRCULAR AND ELLIPTIC ORBITS. N.V. Petersen. Jet Propulsion, May, 1956, pp. 341-351, 368. 27 refs. Consideration of: (a) the general characteristics of circular motion neglecting drag effects; (b) the structure of the atmosphere; (c) the free molecule flow drag, and (d) the equations of motions. An approximate solution to the nonlinear differential equations of motion for near-circular constraint is derived. Results of theoretical prediction of lifetimes for small instrumental satellites having a mass-area ratio of 1 slug/ft.$^2$, satellite bodies having extremely small mass-area ratios of 0.1 slug/ft.$^2$, and large vehicles having mass-area ratios of about 10 slugs/ft.$^2$ indicate that the lifetime increases markedly with altitude and mass-area ratio.

## STRUCTURES

INVESTIGATION OF THE FATIGUE OF EXTRUDED TUBULAR BOOMS. W.A.P. Fisher and H. Yeomans. Gt. Brit., ARC CP 234, 1956. 16 pp. BIS, New York. $0.45. Results of fatigue tests on three lengths of Valetta spar extruded tubing with three different specimens taken from each length. The specimens are the following: (a) extruded tube specimens lightly machined on the outside and having transverse holes drilled through the tube; (b) plain extruded tube with center section reduced to ensure failure in the test; and (c) solid polished bar specimens made from the walls of the extruded tubes. Results show that the unmachined extruded surface of the bore, as used in both the Viking and Valetta spar booms, has an adverse effect on the basic fatigue strength of the tube. Failures in the necked specimens show flows occurring at the inner service as the source of fatigue. Scatter in the endurance of tubular spar booms is largely due to such flows occurring at the side of a transverse hole,

where the local stress is high owing to the presence of the hole.

## Bars & Rods

WYBOCZENIE PRĘTA W OŚRODKU SPRĘŻYSTYM. Jerzy Sułocki. Arch. Mech. Stosowanej (Warsaw), No. 4, 1955, pp. 561-575. In Polish, with summaries in English and Russian. Analysis of an elastic bar with two hinged supports at the ends and with the lower part of the bar surrounded by a homogeneous elastic medium. An exact solution and a transcendental equation are obtained. Numerical values are found as an approximate solution by means of the method of orthogonal functions, the results being corrected by substituting these values in the transcendental equation. The determination of the value of the critical force for any practical case is demonstrated by graphs and tables. Further an approximate method is shown for the solution of the buckling problem in a bar by the Galerkin method of orthogonal functions, assuming a linearly heterogeneous medium.

## Beams & Columns

STRENGTH OF 75S-T INTEGRAL COMPRESSION SKINS IN BOX-BEAMS UNDER PURE BENDING. Sigge Eggwertz. Sweden, Flygtekniska Försöksanstalten FFA Medd. 64, 1956. 42 pp. 38 refs. Investigation of postbuckling stress distribution in unstiffened compression skins for the purpose of developing an empirical formula for calculating maximum bending moment, which can be applied to box beams with two or more webs. Results indicate that there is no accurate theoretical solution for the average stress at failure in the skin of a box beam, but that it is almost exclusively a function of the buckling stress of the compression skin and the corner yield stress. The corner yield stress is close to 0.2% yield stress in compression.

ELEMENTY CIENKOŚCIENNE PODWÓJNIE ZAKRZYWIONE SILNIE ZBIEŻNE. Jerzy Nowiński. Arch. Mech. Stosowanej (Warsaw), No. 4, 1955, pp. 533-560. 14 refs. In Polish, with summaries in English and Russian. Investigation of stresses in thin-walled cantilever beams - axially symmetrical, doubly curved, and with high taper. The skin is assumed to be orthotropic and the Hooke equations are obtained considering normal and shearing forces. Torsion and bending are also considered separately, and a solution is obtained for the case of a spherical shell with a concentrated force at the center.

## Cylinders & Shells

ELASTIC-STRESS WAVES PRODUCED BY PRESSURE LOADS ON A SPHERICAL SHELL. J.H. Huth and J.D. Cole. (ASME West Coast Conf., Monterey, Sept. 12, 13, 1955.) J. Appl. Mech., Dec., 1955, pp. 473-478. Analysis of the problem of stresses in a spherical elastic shell as related to the study of the effect of blast waves on a missile in flight. The assumptions include: the blast wave idealized as a plane wave carrying a pressure jump which moves at constant velocity across the sphere, neglecting the motion of the sphere and its effect on the wave; and the applicability of the momentless thin-shell theory. Results indicate that with the increase of the pressure wave velocity the stresses approach those resulting from a sudden uniform application of the pressure over the entire shell; and that maximum shell stress is directly proportional to the pressure behind the shock and the ratio of shell-radius to thickness, and is dependent on the Poisson ratio and the ratio of pressure-wave speed to the speed of elastic waves in the shell.

## Elasticity & Plasticity

ON A CLASSIFICATION OF NON-HOMOGENEOUS ELASTO-PLASTIC BODIES. W. Olszak. Bul. Acad. Polonaise Sci. (Warsaw), No. 1, 1956, pp. 29-35. 12 refs. Outline of the theory of small-elasto-plastic deformations in nonhomogeneous bodies in the case when the state of stress is not influenced by the strain rate. The approach is based on a generalization of the Hencky and Ilyushin concept.

O PEWNYCH ZAGADNIENIACH BRZEGOWYCH TEORII SPRĘŻYSTOŚCI. Witold Nowacki. Arch. Mech. Stosowanej (Warsaw), No. 4, 1955, pp. 483-502. In Polish, with summaries in English and Russian. Analysis of boundary problems to generalize the methods of structural analysis to the problems of the theory of elasticity. Two methods of solution are presented, one based on the method of forces and the other on the method of deformations. The methods are applicable to the theory of plates for systems with discontinuous boundaries.

STRESS THEORY OF PLASTIC FLOW. D. Trifan. J. Math. & Phys., Apr., 1956, pp. 44-52. 17 refs. Presentation of a mathematical theory of plastic flow for incompressible, isotropic, strain hardening materials exhibiting a gradual transition from the elastic to the plastic state. General stress-strain relations are developed for the above conditions, and for the continuity condition which requires identical differentials at the boundary between the domains of loading and unloading. Conditions are introduced on the arbitrary functions of the stress-strain law, and two absolute minimum principles are given.

## Plates

ANALYSIS OF AN INFINITE PLATE CONTAINING RADIAL CRACKS ORIGINATING AT THE BOUNDARY OF AN INTERNAL CIRCULAR HOLE. O.L. Bowie. J. Math. & Phys., Apr., 1956, pp. 60-71. Investigation of the influence of cracks in the specimen geometry on the strength of the specimen by calculating the elastic strain energy of the system.

THE INFLUENCE OF A BOLT INSERTED IN A HOLE OF AN INFINITE PLATE SUBJECTED TO ONE-DIRECTIONAL TENSION OR COMPRESSION ON THE STRESSES IN THE PLATE. F. Szelągow-

ski. Bul. Acad. Polonaise Sci. (Warsaw), No. 1, 1956, pp. 9-20. Theoretical analysis with the solution based on the Szelągowski solution for the problem of one-dimensional tension of an infinite plate with a circular hole in which a bolt is inserted without clearance, and the relative motion of which is possible neglecting friction.

THE BUCKLING UNDER LONGITUDINAL COMPRESSION OF A SIMPLY SUPPORTED PANEL THAT CHANGES IN THICKNESS ACROSS THE WIDTH. Appendix I - GENERAL SOLUTION OF THE EQUATION OF EQUILIBRIUM FOR PLATES UNDER COMPRESSION. Appendix II - CALCULATION OF THE COMPRESSIVE STRESS REQUIRED TO PRODUCE BUCKLING OF A SIMPLY SUPPORTED PANEL. Appendix III - CALCULATION OF THE STRESS REQUIRED TO PRODUCE BUCKLING OF A CLAMPED PANEL. Appendix IV - DETERMINATION OF THE SHEAR STIFFNESS OF THE PANEL. E.C. Capey. Gt. Brit., ARC CP 235, 1956. 26 pp. BIS, New York. $0.72. Analysis of buckling in a simply supported panel consisting of three strips in which the center strip differs in thickness from the outer strips. Buckling stress and wavelength of buckle are given in terms of thickness and width ratios. For a given width and cross-sectional area, the buckling stress has a maximum value of 1.42 times that of a strip of constant thickness when the control strip is about twice as wide as each of the outer strips, and the thickness of the control strips is about 0.36 times the thickness of the outer strips.

III - GENERAL BENDING OF A PLATE INTO A DEVELOPABLE SURFACE. IV - EDGE CURLING OF A PLATE UNDERGOING OBLIQUE BENDING. V - GEOMETRY OF THE LINES OF MAXIMUM CURVATURE IN BENDING OF THIN PLATES. C. Riparbelli. Cornell U. Grad. Sch. Aero. Eng. OSR TN-56-31; OSR TN-56-32; OSR TN-56-33, Dec., 1955. 15 pp.; 20 pp.; 13 pp. Theoretical analysis to provide information applicable to the study of thin wings presenting a quasi-homogeneous structure, in which the deformation mode is determined by the family of lines of maximum curvature assumed to be straight. Under this assumption a relation between the position of the point to which the lines of maximum curvature converge and the shear resultant is defined. Expressions are derived for the potential energy, to be minimized to define the family of lines of maximum curvature and for the deformation of energy in the general case, as the deformation energy in pure bending multiplied by an amplifying factor which is a function of the convergence. An analysis is also performed to provide a correction of local character when the deformation energy connected with the membrane stresses becomes relevant at all regions except near the edges, owing to the presence of two considerable curvatures, in order to determine the minimum potential energy of the system.

A STUDY OF THE ANTICLASTIC DEFLECTIONS OF THIN PLATES IN BENDING. J.J. Ginoux. Princeton U. Dept. Aero. Eng. Rep. 320 (OSR TN-55-198), Aug., 1955. 19 pp. Computation, based on a Yoler theory, of the maximum values in order to predict the precision of the final nozzle block constructed by a new method of supersonic nozzle design. Results include the discovery of some properties of the Yoler solution in the case of constant spanwise curvature lacking support effects falling into three separate regimes, characterized by different types of deflections; and calculation of the maximum positive and negative deflections as a function of the width and thickness of the plate, presented in graphical form.

TARCZE ORTOTROPOWE POD DZIAŁANIEM SIŁ MASOWYCH. Marek Sokołowski. Arch. Mech. Stosowanej (Warsaw), No. 4, 1955, pp. 427-456. 15 refs. In Polish, with summaries in English and Russian. Derivation of basic equations and solutions of a series of plane problems for the theory of elasticity of an orthotropic body in the case of a load constituted by body forces only, and with the components of the forces represented as arbitrary functions of the coordinates. The solution is obtained by a generalization of the Airy stress function which satisfies a nonhomogeneous, quasi-biharmonic equation, analogous to the equation of an orthotropic plate subjected to bending. Examples of an infinite plate loaded with a concentrated force and of a rectangular plate subjected to forces acting over the whole of the surface are discussed. The weight of the plate is considered in the case of a strip of variable thickness and of a circular plate on a rigid foundation.

## Weight Analysis & Control

MINIMUM WEIGHT DESIGN OF A SIMPLY SUPPORTED TRANSVERSELY STIFFENED PLATE LOADED IN SHEAR. M.F. Symonds. J. Aero. Sci., July, 1956, pp. 685-693. 12 refs. Development of a method to determine the plate thickness, stiffener spacing, and stiffener size and shape which will carry the ultimate load in an unbuckled condition with minimum weight. Curves presented for a given material, 24S-T3 aluminum, show optimum plate shear stress, optimum critical shear stress coefficient, optimum area of stiffener, optimum average plate-stiffener shear stress, and optimum average plate-stiffener thickness plotted against the structural index for three values of the ratio of stiffener spacing to plate depth. Results indicate that the minimum weight is obtained by the use of closely spaced stiffeners, with bending efficiency of the stiffener having a smaller but significant effect. Comparison with other types of shear-carrying members show that the corrugated plate is more efficient at lower values of the structural index.

AN APPROXIMATE SOLUTION TO THE SWEPT WING ROOT CONSTRAINT PROBLEM. D. Howe. Coll. of Aeronautics, Cranfield, Rep. 98, Feb., 1956. 15 pp. Analysis based on the Hemp oblique coordinate theory for the case of a uniform rectangular swept box having closely spaced rigid ribs. Spanwise skin stress distribution is expressed as a polynomial in the chordwise ordinate, with the final equations derived by the theory of minimum strain

energy. An approximate allowance is made for the effect of boom area at the spar-skin joints and is shown to be justified for large boom areas in the particular case of a 45° and 60° sweep. Comparison with experimental results indicates that the solution gives a satisfactory estimation of the constraint effects and, particularly, of the influence of the spar booms.

## THERMODYNAMICS

### Combustion

FLAME PROPERTIES AND THE KINETICS OF CHAIN-BRANCHING REACTIONS. J. Calvin Giddings and J. O. Hirschfelder. U. Wis. NRL Dept. Chem. Rep. SQUID-5, May 3, 1956. 31 pp. Calculations of flame velocity and chemical profiles for a chain-branching system with second order chain breaking. Deviations from the pseudo-steady state are explained in terms of time lag in the formation and destruction of the free radicals. The diffusional effect varies as the second derivative of the free radical concentration with respect to the coordinate. Results indicate: a variation from the purely diffusional theories of flame; the free radicals actually diffuse away from the flame holder in the hot part of the flame where most of the reactions take place; and the flame velocity is almost independent of the coefficients of diffusion of the radicals.

## VERTICAL TAKE-OFF AIRCRAFT

VTOL-STOL AIRCRAFT – PART I. I - JET VTOL. E. R. Hinz. II - SOME CONSIDERATIONS OF THE STOL AIRPLANE. Walter Tydon. III - REMARKS ON THE EFFICIENCY OF STOL AIRCRAFT. A. N. Petroff. Aero. Eng. Rev., July, 1956, pp. 28-39, 44. I - Discussion of VTO aircraft which includes operational advantages over present aircraft, requirements and significant parameters for VTO power plants, evaluation of low and high aspect ratio wings, stability and control problems, weight limitations, and growth potential of a VTO airplane. II - Discussion includes criterion for STOL aircraft, review of some early STOL designs, description of the vectored slipstream principle, and objectives and methods to achieve STOL characteristics. III - Results of a feasibility study of STOL aircraft, which includes discussion of various efficiency parameters for lift-augmented aircraft, and presentation of a concept for a universal boundary-layer control system for all speed ranges.

## WIND TUNNELS & RESEARCH FACILITIES

EXPERIMENTAL EVALUATION OF SUPERSONIC WIND TUNNEL PERFORMANCE WITH SOLID WALL TEST SECTION; SUPERSONIC DIFFUSER; SCAVENGING SCOOP COMBINATIONS. R. V. DeLeo and J. Huerta. USAF ARDC TR-56-6, May, 1956. 82 pp. 25 refs. Experimental investigation of the performance of a solid wall test section with an adjustable diffuser combination, determined both with and without a scavenging duct present within a Mach Number range from 1.5 to 4.4. Results indicate that the minimum starting and operating pressure ratio is dependent on diffuser geometry and that the addition of a scavenging scoop increases the ratios by approximately 10% between Mach Numbers 2.5 and 3.4. At Mach Number 4.4 the pressure ratio is increased by 48%, which is attributed to the fact that the diffuser wall adjustment is limited by the throat setting at which the walls come into physical contact with the scavenging scoop. Use of a near constant area passage at the throat is found to be effective in reducing the pressure ratio requirements.

RESEARCH ON THE DESIGN OF HYPERSONIC NOZZLES AND DIFFUSERS AT HIGH STAGNATION TEMPERATURES. I - DESIGN AND CONSTRUCTION PROBLEMS OF A HYPERSONIC FACILITY AND PRELIMINARY INVESTIGATION OF LIQUID FILM COOLING. R. Hermann, H. Leitinger, W. L. Melnik. Appendix I - PARALLEL AND SERIES OPERATION OF VACUUM PUMPS; INTERCOOLER. F. J. Bollag. Appendix II - CALCULATION OF THE RUNNING TIME OF A BLOW DOWN WIND TUNNEL AND APPLICATION TO THE HYPERSONIC FACILITY AT ROSEMOUNT AERONAUTICAL LABORATORIES. Rudolf Hermann. Appendix III - CRITICAL SURVEY OF VARIABLE-GEOMETRY DIFFUSERS WITH RESPECT TO THE DIFFUSER DESIGN FOR THE HYPERSONIC FACILITY. W. L. Melnik. Appendix IV - AERODYNAMIC DESIGN OF A TWO-DIMENSIONAL MACH NUMBER 7 NOZZLE PROPOSED FOR THE HYPERSONIC FACILITY FOR OPERATION AT HIGH STAGNATION TEMPERATURES. W. L. Melnik. Appendix V - AN INVESTIGATION OF VARIOUS METHODS OF HEATING AIR FOR THE HYPERSONIC FACILITY. R. E. Keppel and F. D. Werner. Appendix VI - HEAT TRANSFER CALCULATION OF A REGENERATIVE TYPE STORAGE HEATER FOR USE IN THE 12" x 12" HYPERSONIC WIND TUNNEL. H. Leitinger. Appendix VII - TOTAL TEMPERATURE PROBES FOR HYPERSONIC CONTRACT. R. E. Keppel and F. D. Werner. Appendix VIII - PRELIMINARY CALCULATION OF NECESSARY COOLANT FLOW TO COOL THE M = 1.92 LAVAL NOZZLE. W. L. Melnik. U. Minn., Inst. Tech. Dept. Aero. Eng. RAL Res. Rep. 127 (WADC TN 55-507), Mar., 1955. 182 pp. 33 refs.

A STUDY OF THE CHINA-FILM TECHNIQUE FOR FLOW INDICATION. R. J. Stalker. Australia, ARL Rep. A.96, Oct., 1955. 33 pp. Results of experiments on the mechanism of formation and the aerodynamic meaning of China-clay streak patterns, showing their intimate connection with a sub-layer of sludge in the liquid film. The definition of the pattern depends on the viscosity of the carrier liquid; the direction of the streaks is the limiting direction of velocity on the surface (the direction of surface shear), unless the skin-friction coefficient is small compared with the gradient of the pressure coefficient. Also includes an analysis of the boundary-layer transition, of the effect of the carrier-liquid viscosity on transition, and of the incidence of shock waves on solid surfaces.

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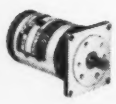

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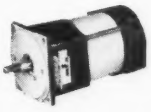

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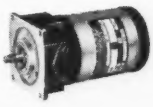

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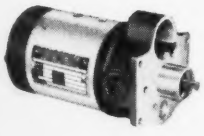

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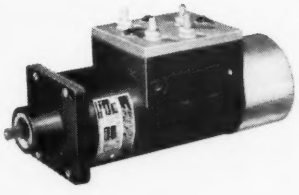

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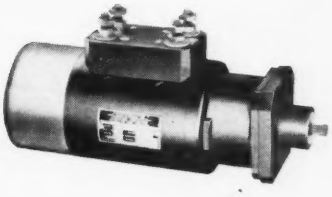

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| E-6415 | 12.6 oz. | 400 cycle ac | .04 hp at 10,500 rpm |
| E-6022 | 2 lb., 1 oz. | 26 v dc | .22 hp at 10,000 rpm |
| *E-6422 | 1 lb., 14 oz. | 400 cycle ac | .15 hp at 9,250 rpm |
| E-6025 | 5.4 lb. | 26 v dc | .75 hp at 9000 rpm |
| E-6032 | 8.25 lb. | 26 v dc | 1.5 hp at 6750 rpm |
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pendix C—**Derivation of Generalized Masses.** Appendix D—**Equations for Evaluating the Aerodynamic Parameters.** Bernard B. Klawans and Harold I. Johnson. *U.S., NACA TN 3543*, Apr., 1956. 42 pp.

**Experimental Study of the Vibration of Cantilevered Isosceles Triangular Plates.** M. P. Kumaraswamy and V. Cadambe. *J. Sci. & Ind. Res., Ser. B*, Feb., 1956, pp. 54–60, 12 refs. Development of a method to obtain higher normal modes of vibration and precise measurements of frequencies, with an analysis of various techniques of exciting natural vibrations.

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## Airplane Design

**T.C.A.'s Viscount Operation.** B. W. Torell. *Can. Aero. J.*, Apr., 1956, pp. 135–139. Evaluation of Viscount 724 trans-

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port; includes general description of the aircraft, with details of wing structures; description of fuel, water-methanol, crash-emergency, deicing, air conditioning, and pressure systems; a report on operating performance; and comparison of maintenance records with other transport types.

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**Static Strength Tests of a Comet I Pressure Cabin.** P. B. Walker. *Gt. Brit. RAE Rep. Struc. 196*, Dec., 1955. 15 pp. Results of tests performed to determine the origin of failure in the G-ALYP and G-ALYY aircraft accidents.

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**Optical Inspection Method for Cockpit Transparencies.** W. A. Heitzman and E. A. Kops. *Aero. Dig.*, Apr., 1956, pp. 28–32. Includes the use of a supplementary drawing to locate the critical areas of distortion and the inspection viewing point with its relative positions; tabulations to determine the limits of distortion for each zone and charts indicating the proper adjustment of those limits to the distortion that will be experienced in the inspection machine; and a set of zone masks and angle-measuring gages.

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**Flight Investigation of the Effectiveness of an Automatic Aileron Trim Control Device for Personal Airplanes.** William H. Phillips, Helmut A. Kuehnel, and James B. Whitten. *U.S., NACA TN 3637*, Apr., 1956. 42 pp. Description of a device for augmenting apparent spiral stability which incorporates a rate-gyro sensing element for switching an on-off type of control that operates the ailerons at a fixed rate through control-centering springs. An analytical study is reported which used phase-plane and analog-computer methods for determining a desirable operational procedure.

**The Quantitative Evaluation of an Aircraft Control System.** R. R. Duddy. (*Gt. Brit., RAE TM Aero. 455*, Jan., 1956.) *8th NATO AGARD Flight-Test Panel Meeting, Rome, Feb. 20–25, 1956.* 5 pp. Introduction to the problem of measuring the ability of an aircraft-pilot system to perform given tasks, with emphasis on gun aiming and landing tests, accuracy, and the pilot's effort.

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**Low-Speed Yawed-Rolling Characteristics and Other Elastic Properties of a Pair of 26-Inch-Diameter, 12-Ply-Rating, Type VII Aircraft Tires.** Appendix—**Interpretation of Results of Dynamic Lateral-Elasticity Tests.** Walter B. Horne, Robert F. Smiley, and Bertrand H. Stephenson. *U.S., NACA TN 3604*, May, 1956. 98 pp.

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**Visual Aids and Their Effect on Landing Success and Safety.** E. S. Calvert. *Gt. Brit., RAE Rep. El. 1486*, Oct., 1955. 19 pp. Report on an approach lighting system installation at the London Airport, with a discussion of underlying principles, the pilot's task, and suggested improvements. Features of the system are the painting of all runways with white markings in accordance with the IACO pattern; the addition of short bars at regular intervals outboard of the edge lights; and the provision of a center line of small, flush-type lights for runways more than 150 ft. wide and of a bar of flashing red lights that becomes visible to aircraft descending below a certain slope.

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**Subtabulation on a High Speed Computer.** *Gt. Brit., RAE TN M.S. 24*, Jan., 1956. 32 pp. Derivation of general formulas for subtabulation at an integral number of subintervals within the original interval, with details of an existing program when the number is a power of two.

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**A Time-Division Multiplier.** M. Lejet Lilamand. *IRE Trans., EC Ser.,* Mar., 1956, pp. 26–34. Description of a time-division multiplier for analog computers which has an accuracy limited only by the stability of the components and the fineness of the adjustment as well as a pass band greater than that of servomechanism multipliers; utilizes a much smaller amount of material than is necessary for diode multipliers with translators having parabolic characteristics; and affords the possibility of changing the diodes without repeating the adjustment process.

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**The Electronic Digital Computer in Aircraft Structural Analysis; The Programming of the Argyris Matrix Formulation of Structural Theory for an Electronic Digital Computer. II—The Use of Preset and Programme Parameters with the Matrix Interpretive Scheme and Their Application to General Purpose Programmes for the Force Method of Analysis.** P. M. Hunt. *Aircraft Eng.,* Apr., 1956, pp. 111–118.

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**On the Wiring of Two-Dimensional Multiple-Coincidence Magnetic Memories.** N. M. Blachman. *IRE Trans., EC Ser.,* Mar., 1956, pp. 19–21. Development of a method to reduce the effects in the disturbance of unselected cores to a level lower than that obtained by Minnick and Ashenhurst by the application of reverse currents to the unselected interrogating wires during interrogation.

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**Engineering Training.** T. R. London. *Can. Aero. J.,* Apr., 1956, pp. 129–134. Review of contemporary aeronautical engineering education in Canada, with a brief historical treatment and discussion of professional status, entrance standards, teaching methods, post-graduate work, and engineering opportunities.

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**Successive Approximation and Expansion Methods in the Numerical Design of Microwave Dielectric Lenses.** Robert L. Sternberg. *J. Math. & Phys.,* Jan., 1956, pp. 209–235. Development of a numerical and analytical method for the design of a microwave dielectric lens of revolution having four perfect focal points symmetrically displaced about the axis of symmetry of the lens, when a number of parameters which determine the lens are preassigned.

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**Increasing the Reliability of Electronic Equipment by the Use of Redundant Circuits.** C. J. Crevellin. *Proc. IRE,* Apr., 1956, pp. 509–515.

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**Analysis of a Regenerative Amplifier with Distributed Amplification.** V. S. Golosman. *Proc. IRE,* Apr., 1956, pp. 533, 534.

**A Comparison of Rotating, Electronic, and Magnetic Amplifier Regulators.** J. P. Montgomery. *Elec. Eng.,* Apr., 1956, pp. 359–363. Review of basic principles, with an evaluation of regulators considering such factors as control accuracy, response time, and stability.

**Component Tolerance Effects in Feedback I.F. Amplifiers.** H. S. Jewitt. *Electronic Eng.,* Apr., 1956, pp. 165–167. Evaluation of component tolerance effects on wideband feedback circuits; includes equations for T and $\pi$ feedback circuits.

**Micro-Power Operation of Silicon Transistors.** E. Keonjian. *Tele-Tech,* May, 1956, pp. 76–78, 138–140, 142. Results of an experimental investigation of the a.c. and d.c. parameters and minimum power levels in the temperature range of −25°C. to +75°C., leading to the design of an experimental two-stage audio amplifier to operate at very low power levels.

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**The Forming of the Negative Electrode of Electrolytic Capacitors.** Tord Bohlin and Åke Lagercrantz. *Ericsson Tech.,* No. 2, 1955, pp. 263–278. Investigation of theoretical conditions, with formulas derived for the decrease of the capacitance at repeated discharges and used for the prediction of load behavior and optimal construction of capacitors.

**Non-Linear DC-Tuned Capacitors.** T. W. Butler, Jr., H. Diamond, and L. W. Carr. *Tele-Tech,* May, 1956, pp. 68, 69, 130–135. Experimental investigation of special techniques for design with low loss at very high frequencies; construction of very small ferroelectric devices with the property of wide variation in capacity in application of d.c. voltage; and measurements of the small signal dielectric losses as a function of frequency and bias field.

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**Complexity in Electronic Switching Circuits.** D. E. Muller. *IRE Trans., EC Ser.,* Mar., 1956, pp. 15–19. Development of a method for estimating the maximum complexity of electronic switching circuits similar to that obtained by Shannon for the case of relay switching circuits having several inputs and outputs.

**The Heating Effect of Steady and Pulsed Current in Resistance Transducers.** Appendixes I, II—**The Heating Effect of a Steady Input on a Wire in Initial Imperfect Contact with the Surrounding Medium.** Appendix III—**The Heating Effect of Pulsed Input.** K. R. Maslen and Mary Coulter. *Gt. Brit., RAE TN Instn. 150,* Nov., 1955. 25 pp.

**The Response Time of Transductors with Negative Voltage Feedback.** F. D. Gill. *Gt. Brit., RAE TN El. 107,* Dec., 1955. 18 pp. Experimental investigation using three 400 cycles per sec. autoself-excited types (single-phase center-tap circuit, three-phase center-tap circuit, a three-phase push-pull circuit). Cores are of mumetal. Ability of the transductors to give half-cycle response and required voltage amplification value are examined.

### *Dielectrics*

**Silicone Insulants; Their Properties and Applications. II.** B. F. W. Hayward. *Electronic Eng.,* Mar., 1956, pp. 115–119.

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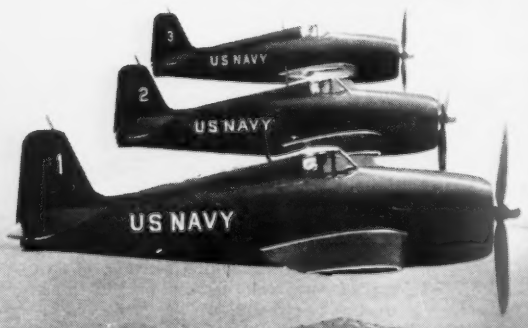


***F6F HELLCATS*** *were the first Grumman Fighters flown by the original Blue Angels when formed in 1946.*

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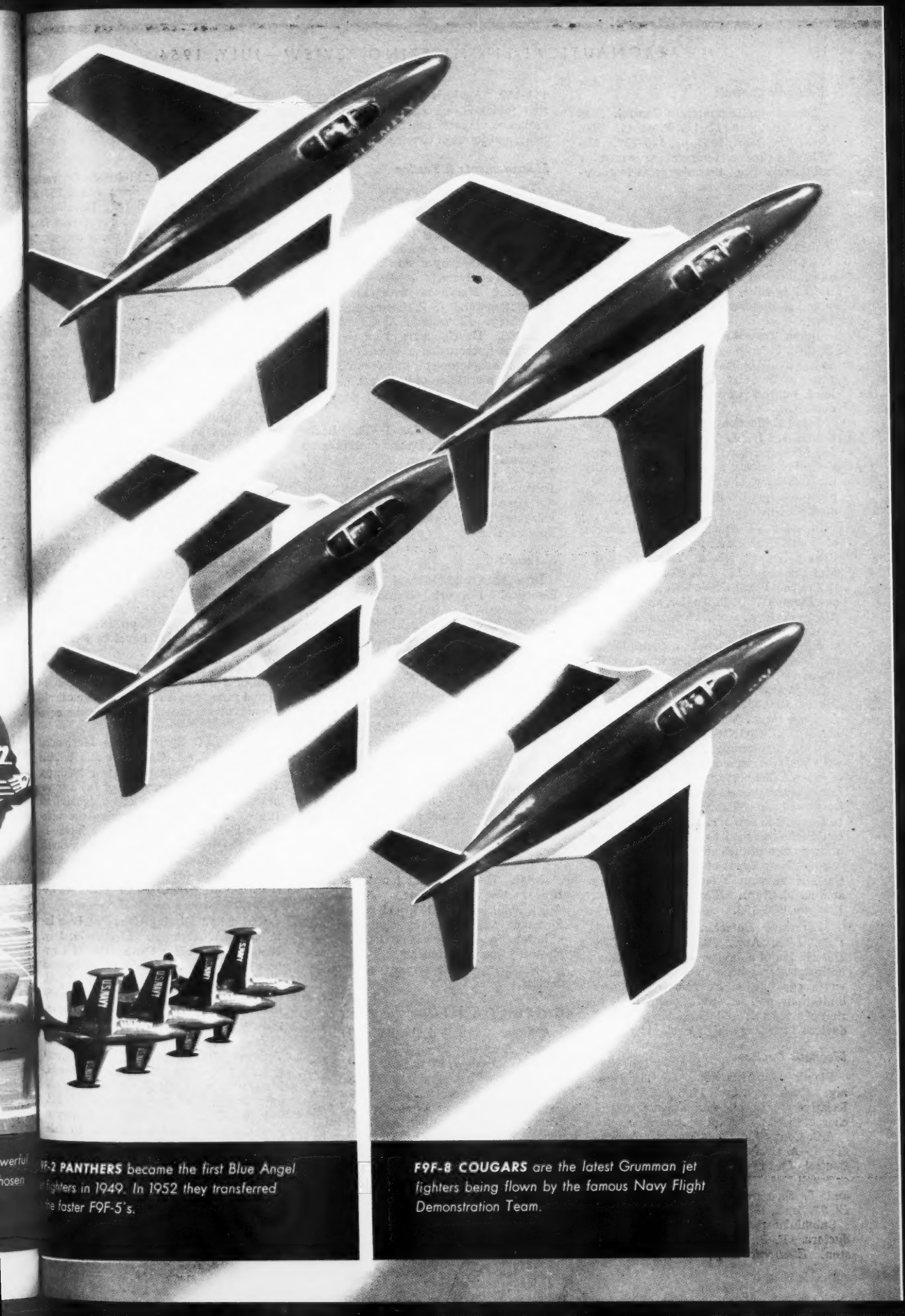


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**F9F-8 COUGARS** *are the latest Grumman jet fighters being flown by the famous Navy Flight Demonstration Team.*

### *Electronic Controls*

**Thermistor Temperature Control.** Paul R. Malmberg and Carl G. Matland. *Rev. Sci. Instr.*, Mar., 1956, pp. 136–139. Development of a temperature controller using small bead thermistors as temperature sensing elements.

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**Using Traveling-Wave Tubes.** Roger E. White. *Electronics*, Apr., 1956, pp. 144, 145. Application of traveling-wave tubes as modulators, mixers, and power level limiters in radar and microwave circuits.

**Beam Deflection Tube Simplifies Radio Compass.** J. M. Tewksbury. *Electronics*, May, 1956, pp. 166, 167. Description of a system to reduce substantially the number of circuit components and to provide a smaller, lighter unit for aircraft application.

**Impedance-Frequency Characteristics of Some Glow-Discharge Tubes.** F. A. Benson and G. Mayo. *Electronic Eng.*, Mar., 1956, pp. 124–126. 12 refs.

**The Gas Filled Diode as a Digital Storage Element.** B. R. Taylor, and R. Bird. *Electronic Eng.*, Apr., 1956, pp. 151–155. Two methods of using gas-filled diodes as storage elements: one in a computer input buffer store, the other in a parallel access computer store.

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**Some New Types of High-Voltage Low Current Vacuum Triodes.** R. Feinberg and K. C. Burn. *Electronic Eng.*, Apr., 1956, pp. 160–162.

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**Plastic-Bound Magnets.** Gerhard Hennig. *Prod. Eng.*, Apr., 1956, pp. 182–186. Relative merits, physical and mechanical characteristics, and applications.

**A.C. Controlled Transductors.** Appendix I—**Analysis of the Direct-Voltage Control of a Single-Element with Positive or Small Negative Signals.** A. G. Milnes and T. S. Law. *Gt. Brit., RAE TN El. 93*, Sept., 1955. 45 pp.

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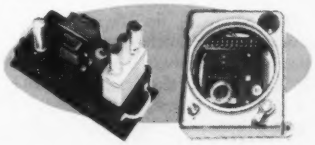

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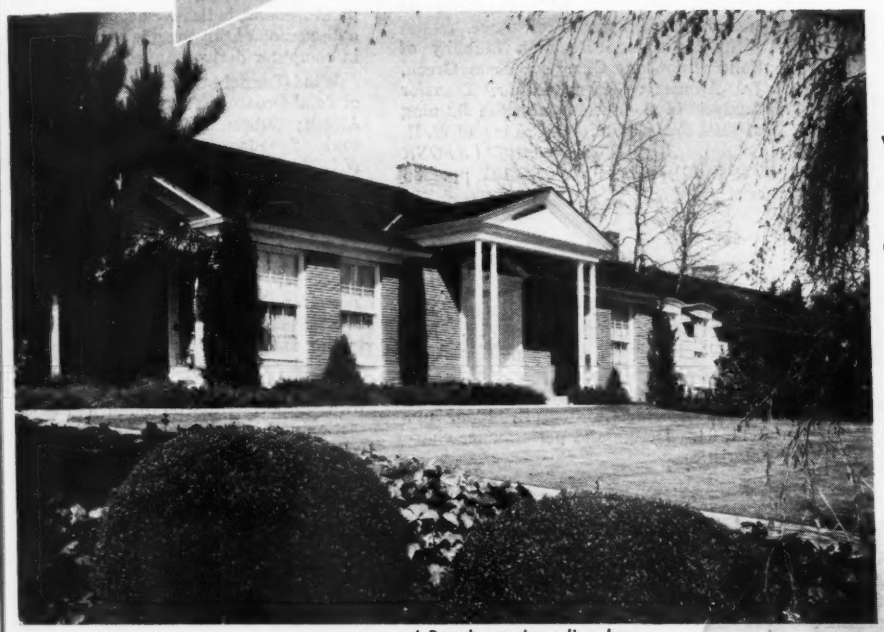

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**Effects of Vibration of Pitot Probe Readings. I, II.** F. A. L. Winternitz. *The Engr.*, Mar. 30, Apr. 6, 1956, pp. 273–275, 288–290. 17 refs. Investigation by towing tank and water tunnel tests and by artificial means in still air and water. Results of observations for pitot tubes with support struts of round and airfoil section and calculations that indicate the critical velocity of flow at which vibration is likely to begin are presented in graphical form and are applicable as a design guide.

**The Measurement of Local Turbulent Skin Friction by Means of Surface Pitot Tubes.** E. Y. Hsu. *U.S., Navy Dept., David W. Taylor Model Basin, Rep. 957*, Aug., 1955. 18 pp. 12 refs. Extension of the pitot tube technique for the determination of boundary-layer flow with adverse pressure gradients.

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**The Floating Integrating Gyro and Its Application to Geometrical Stabilization Problems on Moving Bases.** C. S. Draper, W. Wrigley, and L. R. Grohe. *Aero. Eng. Rev.*, June, 1956, pp. 46–62. 33 refs.

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**Corrugated Metal Diaphragm Performance.** A. V. Kankel and D. C. Whitten. *ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper 55-A-115.* 18 pp. Experimental data indicating the effect of the profile variables, including the number of corrugations, cone angle, arc angle, diameter, and thickness, on diaphragm performance.

### *Tachometers*

**An Airborne Recording Tachometer Using Thyratrons.** F. Walder. *Gt. Brit., AAEE Rep. Res/292*, Feb. 6, 1956. 9 pp. Development of a galvanometer camera recorder to measure rotor speed to an accuracy of ±1 per cent.

### *Temperature Measuring Devices*

**Banc d'Étalonnage Pour Pyromètres a Aspiration Sonique.** J. Maulard. *La*

# Lockheed diversification in action...

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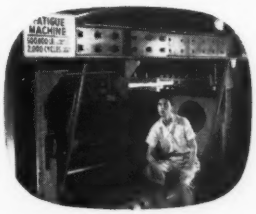


*Fatigue test on Super Constellation skin*

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Stress Analysts
Weight Engineers

*Design study on hydraulic requirements of new transport*

**Design openings**

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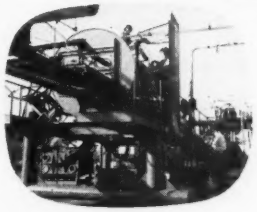

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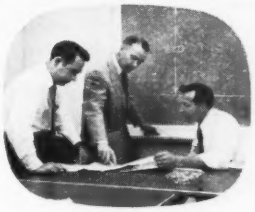

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*Recherche Aéronautique*, Jan.–Feb., 1956, pp. 27–30. In French. Description of the apparatus used for the calibration of sonic intake pyrometers for temperatures ranging between room and 1200°C.

**An Investigation of the Time Response of the N.G.T.E. Sonic Pyrometer.** D. W. Willshire. *Gt. Brit., NGTE Memo. M. 254*, Nov., 1955. 26 pp. Evaluation of a sonic pyrometer for measuring transient jet pipe temperatures in order to provide a better sensing element for control purposes.

**A Sonic-Flow Orifice Probe for the In-Flight Measurement of Temperature Profiles of a Jet Engine Exhaust with Afterburning.** C. Dewey Havill and L. Stewart Rolls. *U.S., NACA TN 3714*, May, 1956. 18 pp.

### *Vibration Measuring Devices*

**Vibration Meter Uses Transistors.** John F. Kinkel and M. Carr Wilson. *Electronics*, Apr., 1956, pp. 127–129. Evaluation of a portable vibration meter for frequencies of 5 to 1,000 cycles per sec. The transistors are immune to vibration effects which would be caused by tube microphonics.

## Machine Elements

### *Bearings*

**The Influence of Plain Bearings on Shaft Whirling.** Appendix I—**Details of Experimental Rig.** Appendix II—**Calculated Flexibilities of a Shaft in Plain Bearings.** Appendix III—**The Effects of Non-Linear Stiffness on the Critical Whirling Speed.** Appendix IV—**The Dry Friction Whirl.** E. Downham. *Gt. Brit., RAE Rep. Struc. 192*, Oct., 1955. 45 pp.

**Load Ratings for Miniature Ball Bearings.** T. S. Kauppinen and R. H. Carter. *ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955, Paper 55-A-117*. 6 pp. Extension of the AFBMA approach with additional computations for comparatively new types in terms of electronic, aircraft, and instrument manufacturing requirements.

**The Short Bearing Approximation for Plain Journal Bearings.** G. B. DuBois and F. W. Ocvirk. *Trans. ASME*, Nov., 1955, pp. 1,173–1,178. 10 refs. Description of an analytical method which eliminates the need for leakage factors and emphasizes the use of charts to obtain the eccentricity ratio, oil-film thickness, peak pressure, friction, and oil flow for a given temperature. Methods are described for estimating a maximum bearing operating temperature, evaluating the effect of elastic deflection and misalignment, and determining a safety factor.

**Power Loss in Elliptical and 3-Lobe Bearings.** O. Pinkus. *Lubrication Eng.*, Mar.–Apr., 1956, pp. 110–116. Derivation of power losses in symmetrical and asymmetrical bearings as a function of bearing parameters and ellipticity, with expressions for a concentric shaft position, assuming a complete oil film and taking into account the incompleteness of the film in the diverging sections. Theoretical and experimental results are compared.

### *Fastenings*

**An unusual Fastener and the Materials Engineering That Made It Possible.** John B. Campbell. *Materials & Methods*, May, 1956, pp. 116–118. Development of vibration-free blind fasteners consisting of a steel stud and lock pin, a nylon cam, and a rubber sleeve, for use as panel fasteners on electronic chassis and as anti-vibration mountings for instruments.

### *Gears & Cams*

**How to Predict Effects of Undercutting Hobbed Spur Gear Teeth.** M. F. Spotts. *Mach. Des.*, Apr. 19, 1956, pp. 123–127. Discussion of the geometrical requirements necessary to secure smooth and continuous action. A theoretical normal pair of involute gears with pressure angle is used to provide an illustrative example of the method.

**Problems of High-Speed Cam Drives and Spring Surge.** M. Feldinger. (*Forschung Gebiete Ing.*, Berlin, Nos. 5, 6, 1955, pp. 159–163; 181–188.). *Engr. Dig.* Mar., 1956, pp. 91–94. Design recommendations based on oscillograms of spring vibrations taken with a load-cell type of pressure pickup located at the stationary end of the spring and on an experimental examination of the effect of disturbances on spring surge.

### *Rotating Discs & Shafts*

**Current Status of Axial-Face Seals.** J. B. Stevens. *SAE Annual Meeting, Detroit, Jan. 9-13, 1956, Preprint 688*. 12 pp. Application to gas turbine main shaft bearings, gear boxes, and accessory pads; limitations due to a sealing media, temperatures, and pressures on rubbing surface speeds; and selection of materials.

**Über das Verfahren von Baranow und seine Erweiterung auf die Ermittlung der Eigenschwingungsformen von Schwingerketten.** H. Schaefer. *Ing.-Arch.*, No. 5, 1955, pp. 307–313. In German. Analysis of the Baranow method for the determination of torsional eigenfrequencies of rotating shafts, with an extension to the study of natural shape vibrations.

**Über die Koppelung der Dehnungs- und Torsionsschwingungen von umlaufenden Scheiben.** K. Zoller. *Ing.-Arch.*, No. 4, 1955, pp. 254–261. In German. Analysis for the determination of basic frequencies and an estimation of second eigenfrequencies, using the Ritz procedure, for a disc having a hyperbolic profile, free external periphery, and strongly stressed internal edge, applying the Hamilton principle to derive exact differential equations for small standing oscillations.

### *Transmissions, Clutches, & Drives*

**Basic Design and Performance Considerations for Friction Brakes and Clutches.** Howard B. Huntress. *Mach. Des.*, Apr. 5, 1956, pp. 113–119. General discussion covering the fundamental braking relationship, maximum drum temperature, radiation heat loss, surface temperature, heat-flow characteristics, drum expansion, and high-temperature effects.

## Materials

**Selection and Application of Spring Materials.** Harold C. R. Carison. *Mech. Eng.*, Apr. 1956, pp. 331–334. Data presented in tabular form to simplify material selection; tables include the following materials: high-carbon, alloy, stainless, and flat high-carbon spring steels; copper- and nickel-base spring alloys; and constant modulus alloys.

### *Ceramics & Ceramals*

**Ceramics as Basic Engineering Materials.** E. J. Smoke and J. H. Koenig. *Mech. Eng.*, Apr., 1956, pp. 315–318. Evaluation of basic properties: melting temperatures, hardness, thermal conductivity, thermal expansion, and strength.

**Cermets for High-Temperature Service.** J. T. Norton. *Mech. Eng.*, Apr. 1956, pp. 319–322. Analysis of compositions based on titanium carbide compared to boride-base and oxide-base specimens for turbojet, gas turbine, and rocket motor applications.

### *Corrosion & Protective Coatings*

**The Corrosion Resistance of Binary Magnesium-Lithium Alloys in Sheet Form.** H. G. Cole. *Gt. Brit., RAE TN Met. 233*, Feb., 1956. 7 pp. Experimental investigation by total immersion in 3 per cent sodium chloride solution and by intermittent sea water spray. Results are applicable to the prediction of probable corrosion behavior of more complex alloys and to the selection of a cladding alloy when it is required to protect a stronger but less resistant base core.

**Corrosion Resistance of Stainless Thread Inserts in Aluminum and Magnesium Alloys.** Paul E. Wolfe. *Prod. Eng.*, Apr., 1956, pp. 176–179. Results of extensive salt spray tests to determine the degree of corrosion to be expected under severe conditions and to evaluate the effectiveness of protective coating and anti-corrosion treatment.

**The Atmospheric Stress-Corrosion of Aluminum-Zinc-Magnesium Type Alloys.** G. Meikle and D. Lewis. *Gt. Brit., RAE Rep. Met. 88*, Oct., 1955. 41 pp. Results of an experimental investigation indicating the extent of the effect of alloy microstructures on the tendency to early failure and on the variation in structure produced by heat treatment to increase resistance.

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**A Dictionary of Metallurgy. XLI—*Sc–Sh*.** A. D. Merriman and J. S. Bowden. *Metal Treatment*, Mar., 1956, pp. 97–104.

**The Fatigue Strength of Specimens Containing Cracks.** N. E. Frost and C. E. Phillips. *Chartered Mech. Engr.*, Mar., 1956, pp. 155–157. Investigation to determine fatigue limit of cracked specimens where the load is completely reversed, or has zero mean load. Results of tests on 0.15 per cent carbon steel, nickel-chromium steel, and aluminum alloy.

**Tension and Torsion Properties of Some Metals Under Repeated Dynamic Loading (Impact).** D. B. C. Taylor and A. Z. Tadros. *Chartered Mech. Engr.*, Feb., 1956, pp. 79–82. Abridged.

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**Materials & Methods Manual No. 126; The New Stainless Steels.** D. B. Roach and A. M. Hall. *Materials & Methods*, Apr., 1956, pp. 137–152.

**Selecting Constructional Steels for Aircraft Design.** C. L. Hibert. *Aero. Dig.*, Feb., 1956, pp. 24–33. Evaluation of alloy steels with respect to toughness, plastic deformation, tempering, fatigue limits, heat treatment, and carbon effects; includes recommendations for design practices.

**Investigation of the $Ni_3Al$ Phase of Nickel-Aluminum Alloys.** Edward M. Grala. *U.S., NACA TN 3660*, Apr., 1956. 24 pp. Experimental study to determine the effects of homogenization treatments and of composition on the tensile properties of as-cast alloys in the $Ni_3Al$-intermetallic-phase region.

**Factors Influencing the Notch Fatigue Strengthening of N-155 Alloy at Elevated Temperatures.** W. S. Hyler and W. F. Simmons. *Trans. ASME*, Feb., 1956, pp. 339–348. 11 refs.

**Factors Influencing the Notch-Rupture Strength of Heat-Resistant Alloys at Elevated Temperatures.** R. L. Carlson, R. J. MacDonald, and W. F. Simmons. *Trans. ASME*, Feb. 1956, pp. 349–358. Investigation of effects of notch geometry, notched and unnotched ductility, modes of deformation and fracture, metallurgical changes, and surface conditions on fatigue life of high-temperature alloys.

**Investigations Into Blade-Root Fixings of High-Temperature Steels.** W. Siegfried. *Trans. ASME*, Feb., 1956, pp. 327–338. Results of tests of creep stress in turbine blade roots with different indentations indicate that good creep properties are obtainable only by brittle materials with a high notch sensitivity.

**Measurement of Total Emissivities of Gas-Turbine Combustor Materials.** S. M. De Corso and R. L. Coit. *Trans. ASME*, Nov., 1955, pp. 1,189–1,197. Development of a method to calculate the emissivity of several metals and ceramic coatings as functions of temperature and surface treatment.

**Strength-Weight Characteristics of Metals for High Speed Aircraft Structures.** B. G. Sloan. *Aero Dig.*, Apr., 1956, pp. 38, 40, 42, 44, 46. Comparison of the physical properties of standard stainless steels, low alloy steels, super alloys, titanium alloys, and precipitation-hardening stainless steels. The advantages of the precipitation-hardening varieties are demonstrated.

**Aluminum Powder Metallurgy Products.** John P. Lyle, Jr. *Materials & Methods*, Apr., 1956, pp. 106–111. Evaluation of physical, short-time, and tensile properties, stress-rupture and creep, fatigue, corrosion, machinability, joining, plating, and anodizing.

**Powder Metallurgy—Now (New Techniques, Improved Properties, Wider Use).** F. V. Lenel. *H. W. Gillet Memorial Lecture, ASTM 58th Annual Meeting, June 28, 1955, Bul.* 34 pp. 32 refs. The evaluation covers high-strength structural parts, powder rolling, cermets, transpiration cooled materials, and aluminum, beryllium, and magnesium powders.

### *Metals & Alloys, Nonferrous*

**New Chromium Plate for Aluminum and Titanium.** Paul J. Topelian. *Materials & Methods*, May, 1956, pp. 120–121. Development of a method to plate aluminum and titanium directly after suitable three-stage surface preparation. The first stage prevents oxidation of the cleaned surface by passivating the metal, the second reactivates the surface during deposition of a bonding coat of chromium, and the third deposits hard chromium to the required thickness.

**Zirconium-Fabrication Techniques and Alloy Development.** C. E. Lacy and J. H. Keeler. *Trans. ASME*, Feb., 1956, pp. 427–433. 25 refs. Discussion of forming processes, neutron-absorption characteristics, mechanical properties, and corrosion resistance.

**Influence of Alloying Upon Grain-Boundary Creep.** F. N. Rhines, W. E. Bond, and M. A. Kissel. *U.S. NACA TN 3678*, Apr., 1956. 16 pp. Measurements of grain-boundary displacement in bicrystals during creep at elevated temperatures, as a function of the copper content in a series of aluminum-rich, aluminum-copper, solid-solution alloys.

**Fatigue des Tôles de Duralumin Avec Piqûres Superficielles.** Enrigue Julio Garcia Sardinero. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 367–372. 10 refs. In French. Experimental investigation of fatigue in duralumin plates which results from corrosion caused by superficial perforations.

**Fatigue Tests on Specimens from Aluminium Alloy B.S.L. 40 Meteor Tail Plane Spar Boom Extrusion.** M. S. Binning and J. T. Ballett. *Gt. Brit., RAE TN Met. 229*, Sept., 1955. 11 pp. Results of tests in Haigh fatigue machines to determine the effect of fatigue strength of mean stress, surface conditions, and a stress raiser in the form of a rivet hole. Polishing the extended surface of plain specimens increases the fatigue strength by approximately 15 per cent.

**Results of Axial-Load Fatigue Tests on Electropolished 2024-T3 and 7075-T6 Aluminum-Alloy-Sheet Specimens with Central Holes.** Charles B. Landers and Herbert F. Hardrath. *U.S. NACA TN 3631*, Mar., 1956. 47 pp. 13 refs.

**Aluminium in Contact with Other Materials.** *ADA Info. Bul. 21*, Dec., 1955. 48 pp. Evaluation of the corrosive behavior of aluminum when used in contact with other metallic and nonmetallic materials. Includes discussion of the nature of metallic corrosion, specific modes of attack, and means to prevent corrosion.

**Some Observations on the Deformation of Grains and Boundaries in Pure Aluminium and Three Binary Aluminium Alloys.** P. J. E. Forsyth and J. C. Terry. *Gt. Brit., RAE TN Met. 225*, July, 1955. 14 pp. 10 refs.

**Stresses and Strains in Cold-Extruding 2S-O Aluminum.** E. G. Thomsen and J. Frisch. *Trans. ASME*, Nov., 1955, pp. 1,343–1,353. 11 refs. Determination of steady-state particle-velocity vectors from gridded, split billets during incremental extrusion steps, and a comparison of velocity patterns with those obtained for lead extrusions with the same billet and die geometry, and with the same high degree of lubrication.

**Design Considerations in Selecting Aluminum Alloys for Welding.** W. M. Rogerson. *Mach. Des.*, Apr. 19, 1956, pp. 103–106.

**Design Principles in Magnesium.** E. V. Schirmer. *Steel Processing*, Mar., 1956, pp. 157–162, 173. Review of the selection of alloys, fabricating methods, arc welding, and finishing methods, and an analysis of new developments.

**New Magnesium Alloy Stands up in "Hot" Ramjet.** Alan V. Levy. *Av. Age.*, Apr., 1956, pp. 28, 29 (2 ff). Evaluation of HK 31 magnesium alloy properties for high temperature use including casting, extruding, welding characteristics, heat treatment, and corrosion-preventive and high-temperature coatings.

**Impurities in Titanium: Phosphorus.** D. A. Sutcliffe. *Gt. Brit., RAE TN Met. 227*, Sept., 1955. 11 pp. Results of hardness, tensile, and impact tests at room temperatures on alloys containing up to 1.13 per cent phosphorus.

**The Determination of Vanadium in Titanium Alloys.** E. G. Cobb and H. J. Allsopp. *Gt. Brit., RAE TN Met. 230*, Nov., 1955. 8 pp. Development of a volumetric method using an internal indicator, with an analysis of the effects of various alloying constituents.

**Some Experiments on the Titanium-Carbon System.** R. L. Bickerdike and G. Hughes. *Gt. Brit., RAE Rep. Met. 89*, Dec., 1955. 33 pp. Determination, using a vacuum quenching furnace with a heating capacity up to 2100°C. for short periods, and up to 1800°C. for long periods, of the melting point of van Arkel titanium and of part of the titanium-carbon phase diagram; the liquidus from the eutectic point up to 1763°C.; and the rate of carbon pickup by molten titanium.

**High Flying Ti.** S. R. Carpenter. *ASME Spring Meeting, Portland, Mar. 19–21, 1956, Paper 56-S-13.* 12 pp. 13 refs. Evaluation of the characteristics of titanium alloys for supersonic aircraft: strength-weight and fatigue properties, the heat-treated condition, and stretch-wrap forming at elevated and room temperatures, with the resulting Bauschinger effect.

**Stainless vs. Titanium for High Speed Aircraft.** R. G. Sloan. *Materials & Methods*, Apr., 1956, pp. 124–127. Comparison of properties of precipitation hardened stainless steel and titanium alloys to meet severe requirements of supersonic flight.

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**How Graphite Performs at High Temperatures.** L. D. Loch. *Materials & Methods*, May, 1956, pp. 126–129. Evaluation of physical, mechanical, and thermal properties and their applications in metallurgy, rocket engines, and nuclear energy.

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Cincinnati 15, Ohio

F. D. Dexter and D. I. Marshall. *SPE J.*, Apr., 1956, pp. 17–19, 40, 60. Development of a method for expressing the apparent viscosity of viscoelastic materials, based on simple extrusion plastometer experiments and applied for finding the roll load forces.

**Plastics as Mechanical-Engineering Materials.** Johan A. Bjorksten. *Mech. Eng.*, Apr., 1956, pp. 337–340. Properties and applications of plastics to eliminate corrosion, including tables of strength properties of glass-reinforced plastics.

**Epoxy Resins Used in Bonded Structures.** *Aero Dig.*, Apr., 1956, pp. 48–50. USAF-sponsored experimental investigation at the Cornell Aero. Lab. to develop a sandwich-type wing with the same strength and stiffness as conventional wings and empennages, but with a reduction of weight. Includes a description of static and dynamic tests on wing sections and of a wind-tunnel test on a 1/10 scale model of the F-80A fighter.

**The Chemistry and Technology of Flexible Polyurethane (Flexalkyd) Foams. Appendix I—Calculation of Residual Carboxyl and Hydroxyl Groups in an Alkyd. Appendix II—Calculation of the Theoretical Gel Point of an Alkyd Resin.** L. N. Phillips. *Gt. Brit., RAE Rep. Chem. 503*, Dec., 1955. 24 pp. 11 refs.

**An Outline of the Characteristics and Properties of Rubber.** R. A. Krause. *Mach. Des.*, Apr. 19, 1956, pp. 128–132.

**Engineering Developments of Rubber—September, 1954, August, 1955.** Lillian Cook and Leora E. Straka. (*ASME Diamond Jubilee Annual Meeting, Chicago, Nov. 13–18, 1955.*) *Mech. Eng.*, Apr., 1956, pp. 341–350. 146 refs.

*Testing*

**Fatigue Under Triaxial Stress: Development of a Testing Machine and Preliminary Results.** J. L. M. Morrison, B. Crossland, and J. S. C. Parry. *Chartered Mech. Engr.*, Mar., 1956, pp. 153–155.

## Mathematics

**Curve Fitting with Orthogonal Polynomials.** Charles R. Sexton. *Prod. Eng.*, Apr., 1956, pp. 171–175.

**On Curves of Minimal Length with a Constraint on Average Curvature, and with Prescribed Initial and Terminal Positions and Tangents.** L. E. Dubins. *Carnegie Inst. Tech. TR 10 (AFOSR-TR-56-12)*, Apr., 1956. 28 pp. ARDC-supported investigation.

**Linear Programming.** A. J. Hoffman. *Appl. Mech. Rev.*, May, 1956, pp. 185–187. Summary of the basic theory and a discussion of the scope of applications, including control of metallurgical processes, electronic equipment, design and aircraft routing.

**Über Stabilität bei nichtlinearen Systemen.** Wolfgang Hahn, *ZAMM*, Dec., 1955, pp. 459–462. In German. Application of the Liapunov Second Method to physical systems with several degrees of freedom which are determined by nonlinear systems of differential equations of the first order. Derivation of conditions for the asymptotic stability of equilibrium as inequations satisfied by nonlinearities.

**A Solution of Tranter's Dual Integral Equations Problem.** J. C. Cooke. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 103–110.

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**Fehlerabschätzung für die zweite Randwertaufgabe der ebenen Potentialtheorie.** G. Bertram. *ZAMM*, Jan.-Feb., 1956, pp. 1–35. In German. Development of a method for the estimation of error for the second boundary value problem of plane potential theory, obtained from the Green representation of solutions for the circle, using conformal mapping.

**The Asymptotic Solution of Linear Differential Equations of the Second Order in a Domain Containing One Transition Point.** F. W. J. Olver. *Philos. Trans. Royal Soc. (London), Ser. A*, Apr. 19, 1956, pp. 65–97. Analysis of the case in which the only transition point in **D** is simultaneously a single pole of $p(z)$ and a double pole of $q(z)$ indicating that the solutions of differential equations have asymptotic expansions which are uniform with respect to $z$ and similar in character to those of previous calculations, in terms of Bessel functions whose order depends on the behavior of $q(z)$ at the transition point.

**Ein graphisches Verfahren zur Lösung von linearen Differentialgleichungen zweiter Ordnung.** W. Vogel. *Ing.-Arch.*, No. 2, 1955, pp. 119–121. In German. Graphical method for the solution of linear differential equations of the second order.

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**On Finite Sum Equations for Boundary Value Problems of Partial Difference Equations.** Herbert Glantz and Eric Reissner. *J. Math. & Phys.*, Jan., 1956, pp. 286–297.

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**Das Verfahren der abgekürzten Iteration für algebraische Eigenwertprobleme, insbesondere zur Nullstellenbestimmung eines Polynoms.** Friedrich L. Bauer. *ZAMP*, Jan. 25, 1956, pp. 17–32. 12 refs. In German. Development of a system of abbreviated iterations for algebraic eigenvalue problems, in particular the determination of zeros of polynomials with complex coefficients.

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**On the Error Function of a Complex Argument.** Joseph Kestin and Leif N. Persen. *ZAMP*, Jan. 25, 1956, pp. 33–40. Transformation leading to the expression of the related function, with formulas for the real and imaginary parts, obtained in terms of elementary functions and two definite integrals, permitting the integration along lines passing through the origin.

**The Determination of Frequency Response from Test Results That Are of Short Duration and not Precisely Periodic.** Leonard Pode. *U.S. Navy Dept., David W. Taylor Model Basin, Rep. 926*, June, 1955. 41 pp.

**Simple Formulas for the Evaluation of Some Higher Transcendental Functions.** Yudell L. Luke. *J. Math. & Phys.*, Jan., 1956, pp. 298–307. 17 refs.

**Contributions to the Statistical Analysis of Categorical Data.** Sujit Kumar Mitra. *N.C. State Coll. Inst. Statistics Rep. 22 (AFOSR-TN-5643)*, Dec., 1955. 146 pp. 39 refs. USAF-supported presentation of two types: multivariate analysis and analysis of variance. Hypotheses are posed and tested for each case.

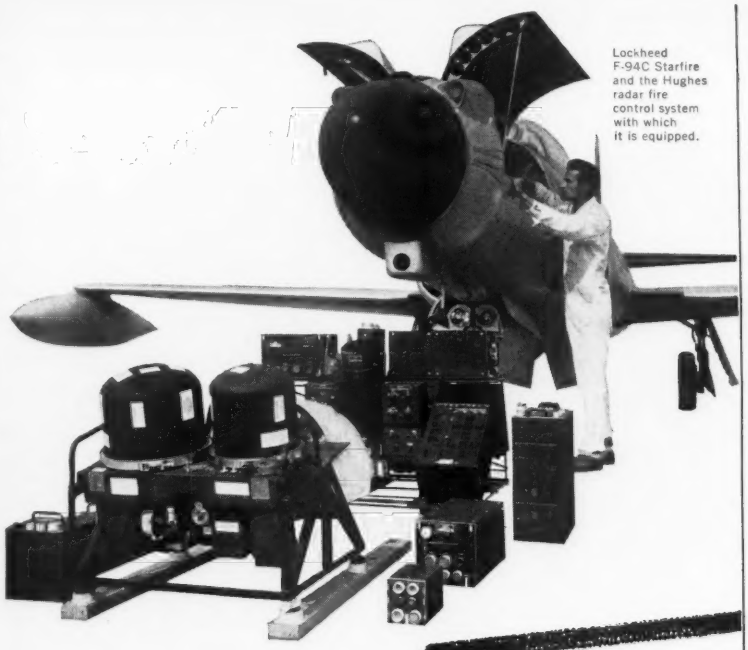
**On Sufficient Statistics When the Range Depends Upon the Parameter.** Walter L. Smith. *N.C. State Coll. Inst. Statistics, Rep. 18 (AFOSR-TN-56-37)*, Nov., 1955. 21 pp. OSR-supported study which strengthens the Davies theorem on the factorability of the probability density function. The restrictive assumptions relating to the analytic form of the relevant density functions are removed, and the theorem is made valid for abstract spaces instead of the real line.

**A Note on Truncation and Sufficient Statistics.** Walter L. Smith. *N.C. State Coll. Inst. Statistics, Rep. 17 (AFOSR-TN-56-36)*, Nov., 1955. 10 pp.

## Meteorology

**The Melting Layer.** Raymond Wexler. *Harvard U. BHMO MR Studies No. 3*, Nov. 30, 1955, 18 pp. 12 refs. AFCRC-sponsored study, with a derivation of the increase in the fall velocity of a spherical melting snowflake based on the assumption that the melting occurs from the outside and leaves the inner low density portion intact, and with an evaluation of the combined effects of changes in the scattering cross section and in the fall velocity of the melting snowflake on the location of the peak echo intensity in the melting layer.

**Turbulence Above the Ozone Layer.** Alan E. Slater. *J. Brit. Interplanetary Soc.*, Jan.-Feb., 1956, pp. 1–6. Analysis to determine if the rate of decrease of temperature with increasing height is sufficient to permit the development of convec-



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tional turbulence; the distribution of air current patterns; and the significant effects of the velocities on a winged vehicle passing through the layer.

**Summary of Locations and Extents of Turbulent Areas Encountered During Flight Investigations of the Jet Stream from October 1953 to May 1954 and November 1954 to July 1955.** Mary W. Fetner. *U.S. NACA RM L55H04a*, Apr. 2, 1956. 10 pp.

## Missiles

**History of German Guided Missiles Development.** NATO, AGARD Seminar, Munich, Apr. 23–27, 1956. Of the 28 papers presented at this meeting, which was sponsored by the Wissenschaftliche Gesellschaft für Luftfahrt (WGL), 20 have been issued in preprint form (text only): Summary of German Developments in Guided Missiles, Th. Benecke. Development and Test of the Missile-Borne Control and Stabilization System Used for the V-1, H. Temme. Guidance and Control with Particular Applications to the Henschel-Missiles, H. Wagner. Contributions to the Guidance of Missiles, E. Fischel. Guidance of Surface-to-Air Missiles by Means of Radar, K. H. Schirrmacher. The Solid Propellant Rocket for the Propulsion of Missiles; Their Design and Performance, H. Vüllers. Summary of the Development and Use of Jet Propulsion. O. Lutz. Development of Peroxide Propellant Rockets, H. Walter. Development and Testing of a Drone for Anti-Aircraft-Target Simulation, W. Kloepfer. Guidance System for Air-Surface Missiles, J. Dantscher. Development of Guidance Systems for Air-to-Air Missiles, J. Dantscher. The Control System of the V-2, O. Müller. The Physical and Technical Development of Infra-Red Homing Devices, E. W. Kutzscher. Summary of the Development of High Frequency Homing Devices, G. Güllner. A Guidance System Using Television, F. Münster. Testing of Ram Jets by Firing as Projectiles, Wolf Trommsdorff. Development of the V-1 Pulse Jet, F. Gosslau. Summary of the Development of Proximity Fuses, F. von Rautenfeld. The Development of the V-2 Rocket Engine, M. Schilling. Spoiler Control of Missiles, G. Ernst. The complete proceedings are scheduled to be published later in the year by AGARD. This volume will include figures and discussions.

**Some Recent Aerodynamic Techniques in Design of Fin-Stabilized Free-Flight Missiles for Minimum Dispersion.** M. W. Hunter, A. Shef, and D. V. Black. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Preprint 543.*) *J. Aero. Sci.*, June, 1956, pp. 571–577.

**Ballistic Missile Performance.** J. William Reece, R. David Joseph, and Dorothy Shaffer. (*IAS 24th Annual Meeting, New York, Jan. 23–26, 1956, Paper.*) *Jet Propulsion*, Apr., 1956, pp. 251–255. Development of a semianalytic method for calculating the range of one-stage ballistic rocket-propelled surface-to-surface missiles in order to obtain a simple approximation of the fundamental complex trajectory problem which would be applicable to a range of 50–500 nautical miles. Computational results in graphical form were obtained with the use of the REAC calculator.

**A Method for Calculating the Mass Ratios of Step-Rockets.** M. Vertregt. *J. Brit. Interplanetary Soc.*, Mar.-Apr., 1956, pp. 95–97.

**Sulle Prestazioni e Sulle Caratteristiche del Missile.** Corrado Casci. *L'Aerotecnica*, Dec., 1955, pp. 291–297. In Italian. Results of an investigation of the influence of drag in missile performance.

## Parachutes

**Drag and Stability of Parachutes.** Helmut G. Heinrich. *Aero. Eng. Rev.*, June, 1956, pp. 73–81. Study of the relationship between the rate of descent and the air resistance in the vertical direction. Design and stability characteristics of several types of parachutes and their application are considered.

**The Effect of Stress Waves on the Strength of Brake Parachute Cables.** B. J. Brinkworth. *Gt. Brit., RAE TN Mech. Eng. 202*, July, 1955. 31 pp. Derivation of equations of transient tension for both ends of a cable under longitudinal impact by a finite mass, with a comparison to the strain-energy solution. Includes analyses of the case of an air-launched body, the possible effects of attenuation in braided cables, the influence of material properties on the velocity of stress propagation, and the maximum elastic stress under impact.

## Photography

**Analysis of a Spin and Recovery from Time Histories of Attitudes and Velocities as Determined for a Dynamic Model of a Contemporary Fighter Airplane in the Free-Spinning Tunnel.** Stanley H. Scher. *U.S. NACA TN 3611*, Apr., 1956. 54 pp. Description of a method using film taken by two simultaneously operating motion-picture cameras.

**Field Evaluation of Askania Cine-Theodolites. I—Test Design and Results.** Ernest Stern. **II—Statistical Analysis.** R. J. Nichol. *USAF, MTC TN-56-18*, Apr., 1956. 81 pp. 12 refs. Includes an outline of methods of analyzing and reducing data obtained from tests with two "in-close" targets, and an examination of several known error sources and their influence on the results. Suggestions are made for further study and for changes in operational procedure.

## Physics

**Introduction à la Mécanique des Milieux Continus.** Paul Anglès d'Auriac. *France, Min. de l'Air PST 306*, 1955. 139 pp. In French. Mathematical analysis of the stresses and deformations in isotropic homogeneous media, using the technique of linear transforms and algebraic matrices.

## Power Plants

**Guided-Missile Propulsion.** T. J. Keating. (*IAS 24th Annual Meeting, New York, Jan. 23–26, 1956, Preprint 636.*) *Aero. Eng. Rev.*, June, 1956. pp. 67–70. Developmental appraisal of the relative merits, potentialities, and performance reliability of solid and liquid rockets, ramjets, and pulse-jets as compared with turbojet and piston engines. The solid rocket is considered the simplest and most reliable of the propulsion devices applicable for JATO boosting of longer range missiles.

### *Atomic*

**Nuclear Reactors for Power Generation.** B. L. Goodlet. *The Engr.*, Apr. 13, 1956, pp. 328–333. Analysis of reactor designs, considering the fast neutron, pressurized water, boiling water, and graphite-moderated reactors; includes discussion of solid fuel elements and the heat removal problem.

**Zur Verwendung von Kernenergie für Staustrahltriebwerke.** H. J. Kaeppeler. *Astronautica Acta*, Mar., 1956, pp. 48–52. In German. Description of a direct method to generate electrical current by collecting the electrons liberated in $\beta$-decay of various elements in a $\beta$-decay battery. The estimate of weight-to-power ratios of ram-jets is compared with that of ion rockets.

**Self Shielding in Rectangular and Cylindrical Geometries.** Harold Schneider, Paul G. Saper, and Charles F. Kadow. *U.S., NACA TN 3661*, Apr., 1956. 40 pp. Solutions of the flux equations of the steady-state diffusion theory ($P_2$) and the transport theory ($P_3$) for multiregion cells of rectangular and cylindrical geometries, representing a given arrangement of moderator, fuel, and cladding.

### *Jet & Turbine*

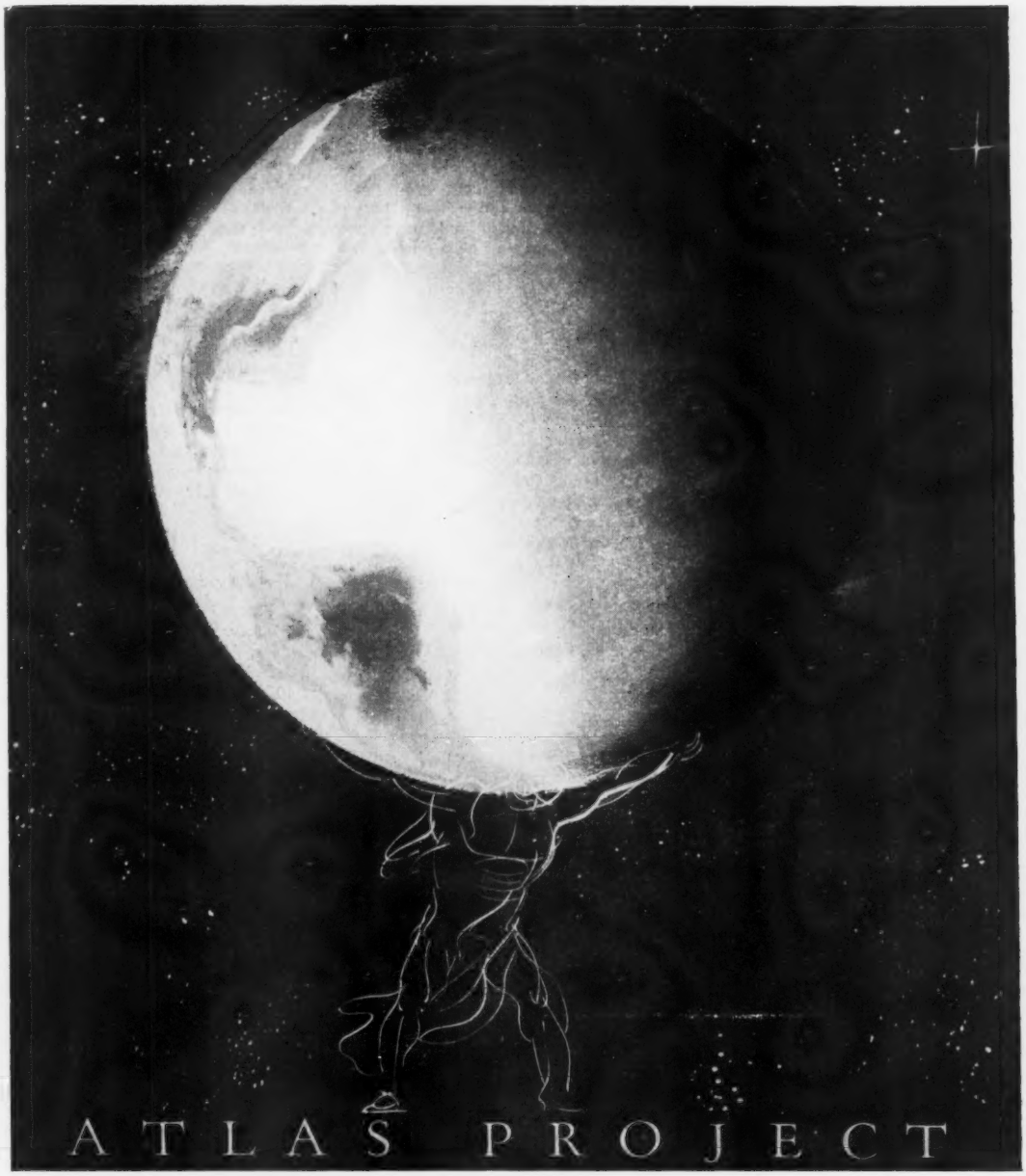
**Hot Turbines.** D. G. Ainley. (*RAeS Paper*, Mar., 1956.) *Flight*, Mar. 16, 1956, pp. 292–295. Abridged. Study of means for increasing turbine inlet gas temperatures with emphasis on methods of cooling turbine blades to prevent failure at the higher operating temperatures.

**The Influence of the Gas-Turbine Axial-Flow Aero-Engine on Blade Manufacturing Methods.** R. R. Whyte. *Chartered Mech. Engr.*, Apr., 1956, pp. 204, 205. Abridged.

**A Pod-Mounted Gas-Turbine-Driven Auxiliary Power Unit.** Ralph Kress. *ASME Spring Meeting, Portland, Mar. 19–21, 1956, Paper 56-S-10.* 13 pp. Design, construction, and requirements of an auxiliary power unit for the Convair C-131B airplane, with specifications of the pod which provides a.c. and d.c. electric power to the aircraft. The unit depends on the aircraft engines or systems for fuel and starting power only and is equipped with a fire-detection and extinguishing system and air inlet anti-icing provisions.

**A Review of Some Combustion Problems Associated with the Aero Gas Turbine.** J. S. Clarke. *J. RAeS*, Apr., 1956, pp. 221–237; Discussion, pp. 237–239; Author's reply, pp. 239, 240. 10 refs. Developmental survey based on experiences and detailed studies of the burning of atomized sprays.

**Choice of Design for an Advanced Turbojet.** F. H. Keast. *CAI Annual Gen. Meeting, Montreal, May 3, 4, 1956, Paper.*

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20 pp. Analysis of the effect of size and design parameters on engine weight and fuel consumption.

**Generalized Turbojet Performance Equations for IBM Calculation.** Victor P. Kovacik. *USAF WADC TN WCLP 55-39*, Mar. 3, 1955. 23 pp. Development of methods for power-plant design point study including the variation of corrected engine r.p.m. with corrected compressor airflow, and data for compressor efficiency versus corrected engine r.p.m.

**Lycoming T 53; America's First Free-Turbine Aero Engine to go into Production.** *Flight*, Apr. 27, 1956, pp. 509.

**Fuel Control and Burning in Aero-Gas-Turbine Engines (James Clayton Lecture).** E. A. Watson. *Chartered Mech. Engr.*, Feb., 1956, pp. 91–127. Survey of investigations covering the problems of supplying the combustion chamber with an appropriate amount of fuel at the required pressure under all conditions of operation, both in steady running and under rapidly varying conditions of acceleration and deceleration; burning the maximum amount of fuel in a given volume of combustion chamber at approximately 100 per cent efficiency; and ensuring immediate ignition when starting at ground level and under operating conditions at high altitudes in the case of one engine being inoperative. Includes analysis of fuel and centrifugal pump operation; pressure, flow, acceleration, speed and temperature control; governing systems; ducting from compressor to combustion chamber; combustion zone; methods of creating turbulence; and direction of fuel entry.

**A Standard Gas Turbine to Burn a Variety of Fuels.** G. B. R. Feilden, J. D. Thorn, and M. J. Kemper. *Chartered Mech. Engr.*, Mar., 1956, pp. 150–152. Analysis of particular geometrical requirements in mounting the gas-turbine rotor and the stator elements and of the geometry of combustion chambers for good combustion efficiency with any type of fuel.

**Performance Criteria of Gas-Turbine Combustion Chambers; a Method of Comparison and Selection for the Designer.** D. B. Spalding. *Aircraft Eng.*, Apr., 1956, pp. 104–110. 12 refs.

**Jet Engines—What Price Power.** V. L. Schatz, A. L. Wynn, and R. W. Remke. *SAE Annual Meeting, Detroit, Jan. 9–13, 1956, Preprint 669.* 10 pp. Discussion of maintenance aspects of the J-47 engine installed in the B-47 medium-bomber; statistics compiled from operational experiences; an examination of periodic inspection routine; and a presentation of cost specifications.

**Turbine Engine Overhaul Problems—A Challenge to the Air Transport Industry.** Norman R. Parmet. *SAE Annual Meeting, Detroit, Jan. 9–13, 1956, Preprint 670.* 8 pp.

**Il Turbogetto con Postbruciatore, Propulsore per Velocità Supersoniche—Limiti Probabili per Barriera Termica Interna ed Esterna.** Gaspare Santangelo. *L'Aerotecnica*, Dec., 1955, pp. 307–318. In Italian. Investigation of basic phases of turbojet engine operation in the subsonic range. Includes study of the afterburner as a means for temporarily increasing the thrust.

**Accelerated Service Testing of Turbo-Prop Engines in USAF Test Bed Aircraft.** Claude W. Smith. *SAE Annual Meeting, Detroit, Jan. 9–13, 1956, Preprint 671.* 11 pp. Description of the test program for the evaluation of engine and propeller reliability, with an outline of specific objectives such as the accumulation of maximum flying time in minimum elapsed time; the collection of data on technical and maintenance problems and supply consumption; and the determination of variations in performance of engines, propellers, and associated control systems with operational usage.

**Performance and Operational Studies of a Full-Scale Jet-Engine Thrust Reverser.** Robert C. Kohl. *U.S., NACA TN 3665*, Apr., 1956. 38 pp. Experimental investigation, under both stationary and taxi conditions, with an axial-flow turbojet engine equipped with a hemispherical target thrust reverser pylon-mounted under the wing of a cargo airplane. Includes measurements of the heat-rise patterns and rates resulting from impingement of the reversed hot gases on a simulated lower wing surface.

**Experimentelle Ermittlung von Messgrössenfeldern an hochtourigen Turbinenläufern.** Karl Leist. *ZFW*, Mar.-Apr., 1956, pp. 128–140. In German. Experimental investigation of the structure of local distribution of parameters on high-speed turbine rotors.

**The Fouling of Turbine Blading by the Products of Combustion of Pulverised Fuel. IV—The Effect of Blading Design, and of Inertial De-Dusting.** Appendixes I, II—**Method of Estimating the Centrifugal Field Strength Along the Concave Surface of the Blade.** Appendix III—**Design and Performance of the High Efficiency Separator.** R. I. Hodge. *Gt. Brit. NGTE Memo. M. 253*, Dec., 1955. 39 pp.

**Interprétation des Enregistrements de Vibrations d'Aubes de Compresseurs Axiaux.** M. G. Brenet. *Tech. et Sci. Aéronautiques*, No. 6, 1955, pp. 378–383. In French. Development of practical methods for the control of blade vibrations during axial compressor tests.

### *Reciprocating*

**Injection Phenomena in High-Speed Diesel Engines.** Appendix I—**Calculation of Reflected Wave at Injector.** Appendix II—**Pischinger's Formula for Calculating Wave Pressures When a Volume is Present.** Appendix III—**Reflection of Waves Against a Volume.** H. Wassenaar. *IME Auto. Div. Proc.*, No. 9, 1954–55, pp. 247–260; Communications, pp. 261–266.

**Rheolineare Drehschwingungen in Kolbenmotoren.** F. Weidenhammer. *Ing.-Arch.*, No. 4, 1955, pp. 262–269. 13 refs. In German. Calculation of rotational oscillations of a piston-engine crankshaft, taking into account the effect of the reciprocating parts, with a derivation of a system of linear differential equations having periodic coefficients.

### *Rocket*

**Heat Transfer Problems in Rocket Motors.** H. Ziebland. *J. Brit. Interplanetary Soc.*, Sept.–Oct., 1955, pp. 249–264. Description of two experimental investigations on the radiation from combustion gas mixtures, with a discussion of the influence of high pressures and temperatures on the emissivity of nonluminous gases; heat transfer between fast moving gas streams and bounding walls; and the conditions on the coolant side of the wall, including the phenomenon of boiling heat transfer in its various regimes.

**Sun-Follower for High Altitude Sounding Rocket.** D. D. Terwilliger and G. J. Granros. *Jet Propulsion* Apr., 1956, pp. 275–277. Design and performance of a spectrograph unit mounted in a research rocket nose to measure solar radiation. The sun is tracked on both elevation and azimuth axes, and data from photoelectric cells are telemetered to ground receivers.

## Production

### *Metalworking*

**Plastic Working of Metals.** W. S. Wagner. (*ASME Annual Meeting, New York, Nov. 28–Dec. 3, 1954, Paper 54-A-64.*) *Trans. ASME*, Feb., 1956, pp. 401–405. Review of the plasticity phenomena associated with the thermoplastic and crystoplastic states, including such fundamentals as work hardening and deformation strength, aging, and the relationship between per cent reduction of area and true strain, as measures of the extent of plastic working.

**Plasticity Equations and Their Application to Working of Metals in the Work-Hardening Range.** E. G. Thomsen. *Trans. ASME*, Feb., 1956, pp. 407–412. 17 refs.

**Metal-Bonding; Applications of the Redux Process in the Fokker Friendship.** James Hay Stevens. *Aircraft Prod.*, Apr., 1956, pp. 150–155. This evaluation of the Fokker structural design program covers tests made on comparative panel-specimens in order to establish optimum structural forms and to make a comparison with other methods of metal joining, and inspection and quality control requirements.

**The Metal Bonding of Assemblies for the Canadair CL-28 Maritime Reconnaissance Airplane.** J. J. Waller. *Can. Aero. J.*, Apr., 1956, pp. 122–128. Selection of adhesive and bonding equipment, pretreatment of aluminum parts, fitting-up of parts to be bonded, application and curing of the adhesive, finishing treatment, and inspection of assemblies.

**Designing for Investment Casting.** John E. Srawley. *Prod. Eng.*, Apr., 1956, pp. 166–169. Advantages and limitations of the method; tolerances obtainable; types of pattern materials and casting alloys; preparation of alloy specification; and inspection procedures.

**Forgings and Modern Fighter Airplane Producibility.** C. R. Kramer and A. Kastelowitz. *SAE Annual Meeting, Detroit, Jan. 9–13, 1956, Preprint 680.* 14 pp. Review of forging techniques developed in the design and production of the F-84F

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**The Effect of Heat Treatment on the Polishability of Mold Steels.** E. E. Lull. *SPE J.*, Apr., 1956, pp. 30, 31, 39. Investigation of carburization and quenching cycles to determine their effect on surface defects encountered in polishing.

### *Nonmetalworking*

**Compression and Transfer Molding of Guided Missile Parts.** L. B. Keller and W. R. McGlone. *SPE J.*, Apr., 1956, pp. 32–39. Analysis of the application of plastics in guided missiles; includes requirements of parts, materials, molds, molding process, and strength characteristics.

### *Production Engineering*

**Airworthiness.** Horace Smith. *J. SLAE*, Feb., 1956, pp. 3–12. Outline of the general pattern as a standard of reliability and durability.

**Special Report: Improve Quality, Reduce Costs, Through Better Materials Selection.** *Materials & Methods*, May, 1956, pp. 135–158. Case histories of 64 manufactured products in terms of longer service life, improved performance, reduced material, fabrication and maintenance costs, and design flexibility.

### *Tooling*

**Economy Tooling.** R. J. Higman. *Can. Aero. J.*, Apr., 1956, pp. 115–121. Discussion of tooling costs to meet present technical requirements, with consideration of limited quantity production. Includes statistics, photographs, and diagrams comparing high- and low-production philosophies.

**Green Linnet: A Copy-Milling Machine Designed for High Rates of Metal-Removal in Light-Alloy.** *Aircraft Prod.*, Apr., 1956, pp. 142–148.

### *Welding*

**The Arc Welding of Aluminium.** *ADA Info. Bul. 19*, Dec., 1955. 92 pp. Description of the properties of the arc and of aluminum in relation to the process; tabulation of the weldability of wrought and casting alloys; evaluation of various methods including the inert-gas shielded, metal, carbon, and atomic hydrogen methods. Generally discussed are safety precautions, economics, working, inspection and testing of welds, strength and design of joints, selection of method, and arc cutting.

**Weld Repair of Aircraft Quality Magnesium Castings.** W. A. Beck. *SAE Annual Meeting, Detroit, Jan. 9–13, 1956 Preprint 676.* 26 pp. Review of equipment, techniques, and recommendations for repairing sand and permanent magnesium aircraft castings.

**Designing Welded Joints for Dissimilar Steels.** Helmut Thielsch. *Mach. Des.*, Apr. 5, 1956, pp. 97–103. Tabulated recommendations for filler metal selection and for preheat and postheat treatments. Other possible combinations depend upon the materials involved or on the service environment.

## Propellers

**"Shush" These Props are Synchrophased!** Charles B. Brahm and G. E. Sanderson. *SAE J.*, Apr., 1956, pp. 50–53. Description of hydromatic synchrophasing propellers, including evaluation of effectiveness in reducing cabin noise level.

**Turboprop Controls Must Include Anti-Windmilling Device.** Mark E. Kirchner. *SAE J.*, Apr., 1956, pp. 56–59. Evaluation of automatic controls to prevent windmilling. The harmful effects of windmilling on control and performance are analyzed, and two devices, the autofeathering control and the automatic decoupler, are described.

## Rotating Wing Aircraft

**Evolution of the Helicopter.** Igor Alexis Sikorsky. *IAS Student Branch Meeting, Rensselaer Polytech. Inst., Troy, Mar. 14, 1956, Paper.* 36 pp. 17 refs. Examination of speed limitations; means of delaying blade stall; effect of compressibility and stalling on the rotor performance; design for operational efficiency; performance parameters; climb; gross weight and payload; range; and power-off descent.

**Induced Aerodynamics of Helicopters. III.** P. R. Payne. *Aircraft Eng.*, Apr., 1956, pp. 123–129. Calculation of performance data using simple energy relations; includes consideration of the variation of mean drag coefficient with tip speed, calculation of flapping angles, and twin rotor interference in hovering and forward flight.

**The Application of the Jet Flap to Helicopter Rotors.** E. J. Richards and J. P. Jones. *J. Helicopter Assn. Gt. Brit.* Jan., 1956, pp. 414–423. Results of a tentative analysis which points out the relative merits of the two-dimensional pressure jet for noise reduction on tip jets by using long thin slots, for improvement of the hovering and forward flight efficiency by applying the jet flap principle to blade design, for the increase of the maximum lift coefficient in hovering, and for easing the stalling problems of the retreating blades in forward flight.

**Turbo Powerplants in Pressure-Jet Convertiplanes.** Charles J. Fletcher. *Aero Dig.*, Feb., 1956, pp. 40, 42, 44, 45. Evaluation of a pressure-jet system in which the main power source drives a high-pressure compressor that supplies compressed air to the rotor during vertical flight.

**Aerodynamic Aspects of Helicopter Design; Lecture to the Helicopter Association.** H. Roberts. *Flight*, May 4, 1956, pp. 523. Review of such aerodynamic problems as performance analysis, stability and control characteristics, wind-tunnel and spinning-rig testing, and flight testing and analysis. Includes recommendations for future research work.

**The Mi-1; First Disclosure of the Technical Characteristics of a Russian Helicopter.** *Flight*, Apr. 20, 1956, pp. 444, 445, cutaway drawings. Design, structural, and performance characteristics compared with those of the Sycamore and Dragonfly types.

**Saunders-Roe Skeeter; Development and Construction of the Mark Six.** *Flight*, Mar. 30, 1956, pp. 355–359, 374, cutaway drawing. Design, structural, and performance characteristics.

**Vertol Tandem Rotor Design.** *Av. Age*, Apr., 1956, pp. 36, 37, cutaway drawings. Description of the H-21 helicopter including general arrangement, shafting, upper flight controls, and rotor transmissions.

**Analysis and Comparison with Theory of Flow-Field Measurements Near a Lifting Rotor in the Langley Full-Scale Tunnel.** Harry H. Heyson. *U.S. NACA TN 3691*, Apr., 1956. 162 pp. 15 refs. Experimental investigation under simulated flight conditions at tip-speed ratios between 0.095 and 0.232 and calculated wake skew angles between 75.0° and 85.8°. Data are compared with theory at those locations for which theoretical calculations are available in order to determine the validity of the calculations and the general nature of the flow field.

**The Control of Helicopter Rotor Vibration.** P. R. Payne. *J. Helicopter Assn Gt. Brit.*, Jan., 1956, pp. 327–360; Discussion, pp. 360–368. 14 refs. Detailed analysis of the structural vibration phenomena due to periodic displacement of the rotor hub, with methods of reduction taking into account control systems using the Hafner torque bar.

**Charts for Estimating Rotor-Blade Flapping Motion of High-Performance Helicopters.** Robert J. Tapscott and Alfred Gessow. *U.S. NACA TN 3616*, Mar., 1956. 19 pp. Theoretically derived charts, applicable to flight conditions involving high inflow velocities and large regions of reversed velocity, for calculating directly steady-state, first- and second-harmonic flapping coefficients for rotors having hinged rectangular blades with a linear twist of 0°, −8°, and −16° analyzed for combinations of inflow ratio to blade pitch angle at tip-speed ratios of 0.05 to 0.50.

**Normal Component of Induced Velocity in the Vicinity of a Lifting Rotor with a Nonuniform Disk Loading. I—Development of Induced Velocity Fields by Superposition.** Harry H. Heyson. **II—Symmetry Relations and the Relation Between Radial Load Distribution and the Radial Downwash Distribution in the Wake.** S. Katzoff. *U.S. NACA TN 3690*, Apr., 1956. 45 pp.

**Helicopter Rotor Behavior After Engine Failure in Forward Flight.** W. Stewart and M. F. Burle. *Gt. Brit. ARC R&M 2861*, (Aug. 1951). 1955. 13 pp. BIS, New York. $1.00. Results of calculations of changes in rotor speed following engine failure in forward flight indicate that the loss of blade rotational speed occurs rapidly and that it is dependent on the initial collective pitch setting and independent of forward speed.

**Charts for Estimating Tail-Rotor Contribution to Helicopter Directional Stability and Control in Low-Speed Flight. Appendix A—Theoretical Development—Static Rotor Characteristics. Appendix B—Theoretical Development—Response to Pedal Deflection.** Kenneth B. Amer and Alfred Gessow. *U.S. NACA Rep. 1216*, 1955, 22 pp. 11 refs.

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**Wind-Tunnel Investigation of Effects of Fuselage Cross-Sectional Shape, Fuselage Bend, and Vertical-Tail Size on Directional Characteristics of Nonoverlap-Type Helicopter Fuselage Models Without Rotors.** James L. Williams. *U.S. NACA TN 3645*, Mar., 1956. 39 pp.

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**An Artificial Satellite for the Earth.** V. R. Thiruvenkatachar. *J. Sci. & Ind. Res., Sect. A*, Feb., 1956, pp. 61–63. Discussion of such aspects of space problems as the height of the orbit, the period of revolution and the orbital velocity, and velocity and methods of launching.

**Design Criteria for Minimum Satellites.** S. F. Singer. *Aero. Dig.*, Apr., 1956, pp. 36, 37. Classification in respect to weight and type of orbit (polar, inclined, or equatorial), orientation, telemetering, altitude, orbit eccentricity, and the resulting lifetime and optical visibility.

**Relativistische Zeitdilatation eines künstlichen Satelliten.** F. Winterberg. *Astronautica Acta*, Mar., 1956, pp. 25–29. In German. A study of time dilatation could be made by comparing two quartz-clocks with molecule resonance lines, one installed on the artificial satellite and the other on the surface of the earth.

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**Stand der Festigkeitsforschung im Flugzeugbau und auf anderen Gebieten des Leichtbaues.** Hans Ebner. *ZFW*, Mar.-Apr., 1956, pp. 108–121. 42 refs. In German. Review of investigations of the problem of structural strength, particularly in aircraft construction.

**The Strength of Lugs in Fatigue.** R. B. Heywood. *Gt. Brit. RAE TN Struc. 182*, Jan., 1956. 34 pp. Correlation of data on various types of steel and aluminum alloy specimens of different design to provide general representative fatigue curves and to indicate the principal influencing factors.

### *Bars & Rods*

**The Equations of Motion for Curved Elastic Bars Deduced by the Use of the "Method of Internal Constraints".** E. Volterra. *Ing.-Arch.*, No. 6, 1955, pp. 402–409. Derivation of equations, taking into account the influence of shear and of rotatory inertia by assuming that, during motion, the sections originally normal to the axis of the bar remain plane.

**A One-Dimensional Theory of Wave-Propagation in Elastic Rods Based on the "Method of Internal Constraints".** E. Volterra. *Ing.-Arch.*, No. 6, 1955, pp. 410–420. 12 refs.

**Knickung gerader Stäbe durch Druck und konservative Torsion.** M. Beck. *Ing.-Arch.*, No. 4, 1955, pp. 231–253. 17 refs. In German. Extension of the Ziegler calculations to the problem of buckling of straight rods by pressure and conservative torsion.

### *Beams & Columns*

**Elasto-Plastic Bending of Beams on Elastic Foundations.** Paul Seide. (*IAS 23rd Annual Meeting, New York, Jan. 24–27, 1955, Paper.*) *J. Aero. Sci.*, June, 1956, pp. 563–570.

**The Accuracy of the Substitute-Stringer Approach for Determining the Bending Frequencies of Multistringer Box Beams.** William W. Davenport. *U.S. NACA TN 3636*, Apr., 1956. 28 pp. Evaluation of the substitute-stringer approach to include the effects of shear lag in the calculation of the transverse modes and frequencies of built-up box beams. An exact vibrational analysis is applied.

**Column Formulas—Four Basic Types.** Glen H. Howell. *Prod. Eng.*, Apr., 1956, pp. 139–141. Analysis includes Euler parabolic, straight-line, and Rankine formulas.

**Buckling of Columns with Equal and Unequal End Eccentricities and Equal and Unequal Rotational End Restraints.** P. P. Bijlaard. *2nd U.S. National Congress of Appl. Mech., U. Mich., June 14–18, 1954, ASME Reprint.* 8 pp.

**The Twist Due to Bending Moment in Cantilevers Curved in Plan.** W. Johnson. *J. RAeS*, Apr., 1956, pp. 277–281. An analysis is applied to cases in which a concentrated load is carried at the end of a cantilever and is confined to the simple forms of channel and I-section. It is assumed that each cantilever is perfectly built-in at one end and that the beams are of constant curvature in plan.

**End-Fitting Effects in Strut Tests.** A. H. Chilver. *J. RAeS*, Apr., 1956, pp. 275–277. Investigation using the "tangent modulus" approach in applying the von Kármán-Biot solution to buckling beyond the elastic range.

### *Cylinders & Shells*

**Finite Torsion of Aeolotropic and Composite Cylinders. I.** J. Ramakanth. *ZAMM*, Dec. 1955, pp. 453–459. Application of the Seth solution of the problem of finite torsion of long solid circular cylinder to obtain values for the torsion of isotropic hollow cylinders and hexagonal aeolotropic cylinders. Comparison of results with those obtained by means of the theory of infinitely small compulsion.

**Lower Buckling Load of Circular Cylindrical Shells Subjected to Torsion.** Jun'etsu Niizawa and Yoshimaru Yoshimura. *J. Japan Soc. Aero., Eng.*, Jan., 1956, pp. 1–6.

### *Elasticity & Plasticity*

**On Certain Boundary Problems of the Theory of Elasticity.** W. Nowacki. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 4, 1955, pp. 175–181. Development of two methods for the generalization of the theory of structures, which are applicable only if the state of strain and displacement in the basic system is known and can be used in the theory of plates and discs for systems with discontinuous boundary conditions.

**Über die Dimensionierung dünner Kreisplatten unter exzentrisch aufgebrachten Einzellasten.** Kh. Nasitta. *Ing.-Arch.*, No. 2, 1955, pp. 85–101. In German. Study of the problem of dimensioning thin circular plates subjected to eccentric loads, using the "eccentro-symmetric" coordinates expressing the sectional moments and transverse forces, with a generalized solution of the homogeneous plate equation and with calculation of a function satisfying the boundary conditions and containing an algebraic singularity at the point of application of load. This calculation yields, by a physical interpretation, an approximation solution for the main flexure lines.

**Zur Festigkeitsrechnung bei gemischt elastisch-plastischer Verformung.** Alex Troost. *ZFW*, Mar.-Apr., 1956, pp. 122–128. In German. Development of a method for the evaluation of strain limits in the elastoplastic range.

**Solution of Complex Nonlinear Plastic Structures by the Method of Tearing.** Gabriel Kron. *J. Aero. Sci.*, June, 1956, pp. 557–562. Development of a tensorial method for solving the stresses and deformations in complex statically indeterminate trusses stressed beyond the proportional limit.

**Reine ebene Biegung bei einem nichtlinearen Elastizitätsgesetz.** F. Jindra. *Ing.-Arch.*, No. 5, 1955, pp. 373–378. In German. Study of two-dimensional pure bending under a nonlinear law of elasticity.

**Beitrag zur Theorie der elastischen Ringe mit Berücksichtigung der Wölbbehinderung.** A. Björklund. *Ing.-Arch.*, No. 6, 1955, pp. 421–535. In German. Extension of the Odqvist treatment of open or closed rings of arbitrary cross section, taking into account the effect of curvature of the cross section and using calculations based on the torsion of straight beams. Includes an analysis of the closed ring with concentrated inverted moments and of the closed ring with equally distributed load across the plane of the ring and with equidistant supports.

**Buckling of an Infinite Simply Supported Strip Under Combined Longitudinal Compression, Transverse Compression, Bending, and Shear.** W. H. Wittrick. *Australia, ARL Rep. SM. 234*, Sept., 1955. 41 pp.

**On the Buckling of Bars and Plates in the Plastic Range. II.** Supplement A—**The Differential Quotient $dy/dr$ of Initially Simply Compressed Material as Function of the Later on Added Shearing Stress $r$.** Supplement B—**Determination by Deformation Theory of the Critical Buckling Load of the Onat and Drucker Load Case in the Absence of Initial Eccentricity and Prediction of the Secant Modulus for this Load.** J. P. Benthem. (*Netherlands, NLL Rep. S.423*, Jan., 1954.) *U.S., NACA TM 1392*, Mar., 1956. 79 pp. 48 refs. Translation.

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**Bending of Rectangular Plate with Clamped Edges.** Ching-Sheng Wu. *J. Aero. Sci.*, June, 1956, pp. 601, 602.

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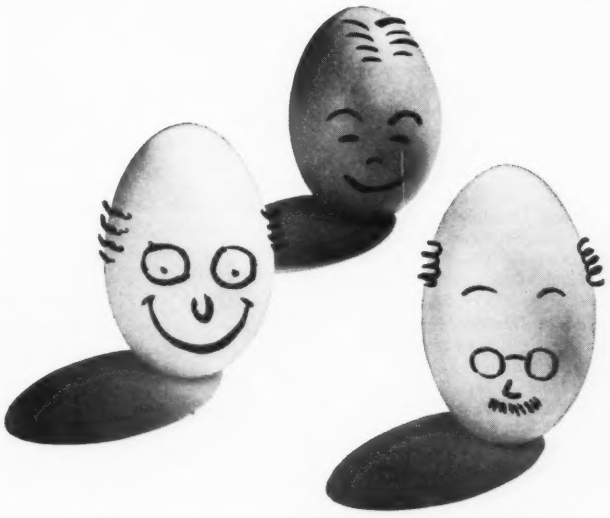

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**Über ein Verfahren zur Bestimmung der Biegemomente von Platten unter Einzellasten.** S. Woinowsky-Krieger. *Ing.-Arch.*, No. 5, 1955, pp. 349–353. In German. Methods for the determination of maximum bending moments in thin rectangular plates under a load uniformly distributed over the central portion of the plate.

**Über die Verwendung von Bipolarkoordinaten zur Lösung einiger Probleme der Plattenbiegung.** S. Woinowsky-Krieger. *Ing.-Arch.*, No. 1, 1956, pp. 47–52. Analysis of the application of bipolar coordinates to the solution of problems of bending of plates.

**Investigation of the Compressive Strength and Creep Lifetime of 2024-T Aluminum-Alloy Skin-Stringer Panels at Elevated Temperatures.** Eldon E. Mathauser and William D. Deveikis. *U.S., NACA TN 3647*, May, 1956. 29 pp.

**On the Theory of Initially Tensioned Circular Membranes Subjected to Uniform Pressure.** J. D. Campbell. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 84–93. Generalization of the Hencky solution of the problem, with a derivation of curves showing the transition between two extreme cases for distribution of incremental stress and strain in the membrane.

**One-Directional Tension of an Annular Plate.** F. Szelągowski. *Bul. Acad. Polonaise Sci.* (Warsaw), No. 4, 1955, pp. 189–193. Equations are derived in order to determine approximately the state of stress in a strip subjected to one-directional tension and having a rigid circular hole, with external stress acting in the same direction. It is assumed that the influence of the hole and its loads disappears within a certain portion of the infinite plate bounded by the circular region of the radius.

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**Neutral Holes in Plane Sheet: Reinforced Holes Which are Elastically Equivalent to the Uncut Sheet.** Appendix I—**The Effect of Bending Stiffness of the Reinforcing Member.** Appendix II—**Finite Stringer Spacing.** Appendix III—**Rib and Stringer-Reinforced Sheet.** Appendix IV—**Other Stress Distributions.** Appendix V—**Test on Model of Parabolic Cut-Out.** E. H. Mansfield. *Gt. Brit., ARC R&M 2815* (Sept., 1950), 1955. 34 pp. BIS, New York. $2.00.

### *Testing*

**Some Fatigue Characteristics of a Two Spar Light Alloy Structure (Meteor 4 Tailplane).** K. D. Raithby and Jennifer Longson. *Gt. Brit., RAE Rep. Struc. 195*, Jan., 1956. 31 pp. Experimental investigation of the effects of mean and alternating load on the endurance of low temperatures, of preloading, and of periodic overloading.

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**The Structural Effects of Kinetic Heating in Supersonic Flight.** Percy B. Walker. *Gt. Brit., RAE Rep. Struc. 189*, Oct., 1955. 14 pp. Study of the basic problem, assuming a simplified structure with a simplified thermal system, with analyses of the adverse effect of kinetic heating, difficulties encountered, thermal insulation and artificial cooling, and developments in thermostructural testing.

**Thermal Shock Stresses in a Cylinder of Rectangular Cross Section.** P. W. H. Howe. *Gt. Brit., NGTE Memo. M.263*, Feb., 1956. 27 pp. Theoretical calculation, using relaxation methods, for one set of values of the length-width ratio of the rectangular cross section, heat-transfer coefficient, and time after the quenching starts.

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**Approximate Analysis of the Reduction in Torsional Rigidity and of the Torsional Buckling of Solid Wings Under Thermal Stresses.** N. J. Hoff. *J. Aero. Sci.*, June, 1956, pp. 603, 604.

**Analysis of the Ultimate Strength and Optimum Proportions of Multiweb Wing Structures.** Appendix—**Web Requirements.** B. Walter Rosen. *U.S., NACA TN 3633*, Mar., 1956. 34 pp. Investigation to determine relative structural efficiency of various types of thin-wing configurations using as a comparison the minimum-weight design of thick-skin multiweb wing structures and considering the minimum structural weight as a function of bending moment, wing chord, depth, and skin thickness.

**Interim Report on Fatigue Characteristics of a Typical Metal Wing.** Appendix I—**Vibration Loading Test Method.** Appendix II—**Calculation and Verification of the Vibration Mode.** Appendix III—**Description of Major Failures.** Appendix IV—**Statistical Analysis of the Data.** Appendix V—**Relation Between the Fatigue Strength of P51-D Mainplanes and Notched 24ST Alclad.** Appendix VI—**Description of the Mechanism of Fatigue Failure.** J. L. Kepert and A. O. Payne. (*Australia, ARL Rep. SM 207*, Jan., 1955.) *U.S., NACA TM 1397*, Mar., 1956. 80 pp. 17 refs.

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**Thermoelasticity and Irreversible Thermodynamics.** M. A. Biot. *J. Appl. Phys.*, Mar., 1956, pp. 240–253. 12 refs. Development of a unified treatment applying methods of irreversible thermodynamics and using the concept of generalized free energy and a new definition of the dissipation function in terms of the time derivative of an entropy displacement. Includes a formulation of general laws of thermoelasticity presented in a variational form and of a minimum entropy production principle; general solutions of the equations of thermoelasticity using the Papkovitch-Boussinesq potentials; and an application of the generalized coordinate method to calculate the thermoelastic internal damping of elastic bodies.

### *Combustion*

**Combustion Studies with a 12000-Curie Gold Source.** Stuart W. Churchill, Alexander Weir, Jr., Leroy F. Ornella, Roy L. Gealer, Robert E. Kelley, and Martin E. Gluckstein. *U. Mich. Eng. Res. Inst. TN 2288-6-T*, Dec., 1955. 53 pp. 12 refs. OSR-sponsored experimental investigation of the effect of nuclear radiation from Au-198 and Au-199 on flat propane-air flames at low pressure, with both the preflame mixture and the flame zone being irradiated.

**The Film Combustion of Liquid Fuel.** H. W. Emmons. *ZAMM*, Jan.-Feb., 1956, pp. 60–71. Investigation of the combustion problem assuming that the mass and heat transfer are the controlling variables that remove the chemical reaction zone from the droplets larger than $10^{-1}$ in. to a region where it is less sensitive to the effects of the droplet itself.

**Flame Speeds in Hydrazine Vapour at Low Pressures.** A. R. Hall. *Gt. Brit., RAE TN RPD 129*, Sept., 1955. 15 pp. 14 refs. Measurements at pressures of 3 cm., 7 cm., and 15 cm. of mercury using the burner method, in which the burner diameter is kept inversely proportional to the pressure and a constant value maintained for the Reynolds Number, in order to make the heat losses from the flame comparable over a range of pressures.

**An Extension of the Theory of Thermal Explosion and Its Application to the Oscillatory Burning of Explosives.** Appendix I—**Boundary Conditions at Critical Depth and Their Effect on the Solution.** D. M. Clemmow and J. D. Huffington. *Gt. Brit., RAE TN RPD 128*, Sept., 1955. 28 pp.

**The Ignition Mechanism of High Explosives.** C. H. Johansson and Henrik L. Selberg. *Appl. Sci. Res., Sect. A*, No. 6, 1956, pp. 439–449. Results of theoretical and experimental investigations indicating the inflammability of an explosive at compression if the air inclusions contain vapors, small particles or drops which give an exothermic reaction when heated, and a similar effect if the explosive forms thin layers between two bubbles or if the bubble wall is uneven with projecting convex sections.

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**Ignition of Combustible Gases by Converging Shock Waves.** James A. Fay and Edward Lekawa. *J. Appl. Phys.*, Mar., 1956, pp. 261–266. OSR-supported theoretical and experimental investigation using Perry-Kantrowitz apparatus to ignite hydrogen-oxygen and hydrogen-air mixtures by converging cylindrical shock waves, with a determination of the shock wave within a cylinder of diameter equal to the quenching distance and of unit height comparable with the minimum spark ignition energy divided by the quenching distance. Includes an analysis of the unsteady heat conduction problem.

### *Heat Transfer*

**Heat Conductivity in Polyatomic or Electronically Excited Gases.** Joseph O. Hirschfelder. *U. Wis. NRL Dept. Chem., WIS-ONR-22*, Apr. 18, 1956. 14 pp. Derivation and improvement for the Eucken correction of the coefficient of conductivity for the internal degrees of freedom of the molecule given by the factor $0.115 + 0.354\ C_p/R$ (where $C_p$ is the heat constant pressure and $R$ is the gas constant). The approximation is valid only if the electronic states are not metastable and the coefficients of diffusion of all the molecular quantum states are equal.

**Measurements of Thermal Conductivity by a Non-Steady-State Method.** B. H. Vos. *Appl. Sci. Res., Sect. A*, No. 6, 1956, pp. 425–438. Results of an evaluation indicate: that for an estimate of heat losses in insulating construction, the steady-state method is most suitable for nonhomogeneous materials and the contribution of radiation to the thermal conductivity can be neglected; that when the contribution of radiation is taken into account and the thickness of the layers applied in the relative constructions is considerably greater than the thickness of the test specimen, the nonsteady-state method is used; and that the nonsteady-state method is applied to measurements of thermal conductivity as a means for the determination of moisture distribution and its changes.

**Experimental Determination of the Thermal-Entrance Length for the Flow of Water and of Oil in Circular Pipes.** J. P. Hartnett. *Trans. ASME*, Nov., 1955, pp. 1,211–1,220. 39 refs. Calculation over a range of Reynolds and Prandtl Numbers, with the imposition of constant-heat-rate boundary numbers and the use of separate flow systems for the heat-transfer tests on each fluid.

**Heat Transfer and Pressure Drop for Viscous-Turbulent Flow of Oil-Air Mixtures in a Horizontal Pipe.** H. A. Johnson. *Trans. ASME*, Nov., 1955, pp. 1,257–1,264.

**Numerical Solutions for Laminar-Flow Heat Transfer in Circular Tubes.** W. M. Kays. *Trans. ASME*, Nov., 1955, pp. 1,265–1,274. 16 refs. Description of a method using the Langhaer solution to provide the velocity profiles introduced into energy equation, with experimental data for two heating conditions: constant wall temperature and constant heat input per unit of tube length.

**An Interferometric Study of Free-Convection Heat Transfer from Enclosed Isothermal Surfaces.** C. D. Jones and D. J. Masson. *Trans. ASME*, Nov., 1955, pp. 1,275–1,281. 13 refs. Includes correlation of data with those for unconfined surfaces, horizontal cylinders, and the vertical surfaces of prisms of small height.

**Turbulent Heat Transfer and Friction in the Entrance Regions of Smooth Passages.** R. G. Deissler. *Trans. ASME*, Nov., 1955, pp. 1,221–1,233. 13 refs. Predictions of the influence of Reynolds and Prandtl Numbers, initial velocity distribution, wall-boundary condition, passage shape, and various fluid properties, with calculations of thicknesses of the thermal and flow boundary layers based on integral heat-transfer and momentum equations.

**Free-Convection Heat Transfer from a Rotating Horizontal Cylinder to Ambient Air with Interferometric Study of Flow.** G. A. Etemad. *Trans. ASME*, Nov., 1955, pp. 1,283–1,289. 14 refs. Experimental evaluation for a range of Reynolds Numbers from 0 to 65,400 and description of a method to extend measurements of the surface temperature up to a rotational speed of 5,250 r.p.m. by means of calibrated and carefully aged thermistor beads, with modifications.

**The Influence of Curvature on Heat Transfer to Incompressible Fluids.** Appendix—**Experimental Comparison of Heat Transfer from Convex and Concave Heating Surfaces.** Frank Kreith. *Trans. ASME*, Nov., 1955, pp. 1,247–1,256. 11 refs.

**Experimental Investigation of Free-Convection Heat Transfer in Vertical Tube at Large Grashof Numbers.** E. R. G. Eckert and A. J. Diaguila. *U.S., NACA Rep. 1211*, 1955. 14 pp. Supt. of Doc., Wash. $0.20. Measurement of local heat-transfer coefficients and temperature fields in the turbulent-flow range within a vertical, stationary tube closed at the bottom, heated along the walls, and having a length-to-diameter ratio of 5. The tube was designed to provide a gravitational field with Grashof numbers of magnitude comparable with those generated by the centrifugal field in rotating blade coolant passages. Air temperature measurements within the tube indicated a thin boundary layer along the heated wall surface and unstable conditions in the airflow.

**The Thermodynamics of Thermal Instability in Liquids.** Harold Jeffreys. *Quart. J. Mech. & Appl. Math.*, Mar., 1956, pp. 1–5. Analysis indicating that the Jeffreys-Bland principle of a stationary eigenvalue in the case of a fluid sphere heated within is an expression of the principle that states that in marginal instability the supply of energy by expansion should balance the dissipation, expressed in terms of the disturbance temperature and equivalent to the Pellew-Southwell and Chandrasekhar form.

**Thermodynamic Properties of Gaseous Nitrogen.** Harold W. Woolley. *U.S., NACA TN 3271*, Mar., 1956. 114 pp. 94 refs. Systematization of NBS-NACA tables including thermodynamic functions for the gas, both real and ideal; transport properties of the gas; vapor pressure of the liquid and of the solid; ideal-gas properties covering specific heat at constant pressure, enthalpy, entropy, and free-energy function; and real-gas properties covering density, compressibility factor, entropy, enthalpy, specific heat at constant pressure, ratio of specific heats, and velocity of sound at very low frequency.

## Vertical Take-Off Aircraft

**Lift and Thrust Creating Systems—Their Application to Short and Vertical Take Off Aircraft.** Karl Irbitis and Frederick C. Phillips. *CAI Annual Gen. Meeting, Montreal, May 3, 4, 1956, Paper.* 67 pp. Analysis of the principles of such lift- and thrust-producing systems as the wing, the ram-jet, and the rocket. Includes a study of the relationship between the wing and the ram-jet; the possible motions of the wing; the whole family of wing-related systems from rotor to turbojet; high-lift modifications of the fixed wing, including flaps, slats, and boundary-layer control; and the application of the systems to the design of various vertical take-off and landing (VTOL) and short take-off and landing (STOL) aircraft.

**Preliminary Investigation of the Effectiveness of a Sliding Flap in Deflecting a Propeller Slipstream Downward for Vertical Take-Off.** Richard E. Kuhn and Kenneth P. Spreemann. *U.S., NACA TN 3693*, May, 1956. 25 pp. Results of tests on a wing equipped with a sliding flap and a leading-edge slat conducted in a Langley Aero. Lab. static-thrust facility. The sliding flap, in comparison with a plain flap and a slotted flap previously tested, makes possible a more forward location of the point at which flow turning begins.

**Investigation at Zero Forward Speed of a Leading-Edge Slat as a Longitudinal Control Device for Vertically Rising Airplanes that Utilize the Redirected-Slipstream Principle.** Richard E. Kuhn. *U.S., NACA TN 3692*, May, 1956. 33 pp.

**Hovering-Flight Tests of a Model of a Transport Vertical-Take-Off Airplane with Tilting Wing and Propellers.** Powell M. Lowell, Jr., and Lysle P. Parlett. *U.S., NACA TN 3630*, Mar., 1956. 23 pp. Investigation of the take-off, landing, and hovering-flight characteristics of a four-engine transport. The remotely controlled free-flight model that was employed has four propellers distributed along the wing with thrust axes in the wing-chord plane which are rotated 90° with respect to the fuselage in order to produce direct lift for hovering flight with the fuselage horizontal.

## Water-Borne Aircraft

**A Note on Partial Cavitation of Flat Plate Hydrofoils.** A. J. Acosta. *CIT Hydrodynamics Lab. Rep. E-19.9*, Oct., 1955. 9 pp. Extension of the Tulin method to the case of the cavitation bubble being smaller than the hydrofoil chord.

**Pressure Distribution on a Hydrofoil Running Near the Water Surface.** Blaine R. Parkin, Byrne Perry, and T. Yag-Tsu Wu. *J. Appl. Phys.*, Mar., 1956, pp. 232–240. 17 refs.

## AERODYNAMICISTS

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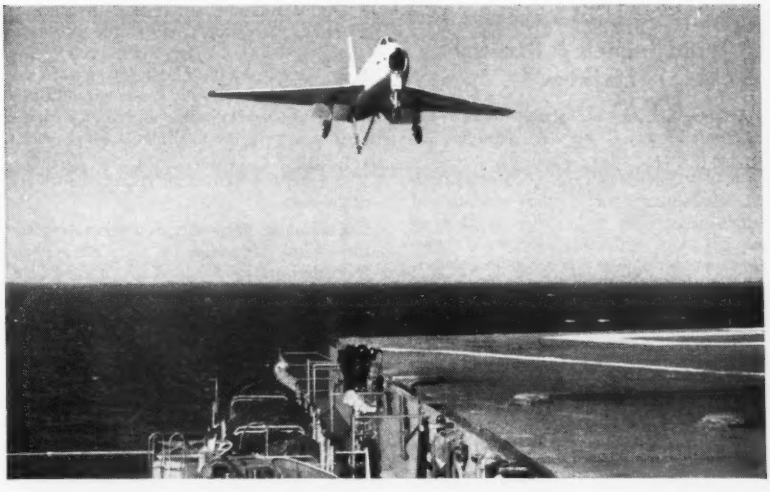

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**Towing Tank Tests to Determine the Water Drag of the Hull of a Jet Propelled Flying Boat Fighter (Spec. E.6/44) and Comparison with Full Scale Measurements.** R. V. Gigg, A. C. Kurn, and J. K. Friswell. *Gt. Brit., MAEE Rep. F/Res/263 (Revised)*, May, 1955. 41 pp.

## Wind Tunnels & Research Facilities

**Attenuation in the Shock Tube. I—Laminar Flow.** Robert N. Hollyer, Jr. *J. Appl. Phys.*, Mar., 1956, pp. 254–261. 30 refs. Calculation of a correction of the ideal theory for viscous stresses and heat losses arising from the interaction of the gas flow with the tube walls, considering the boundary layer as a distribution of sinks of energy and momentum, with a determination of the change in shock strength due to a sink located at a fixed distance behind the shock front, the interaction between the expanding compression chamber gas and the wall being neglected.

**Experimental Investigation of Water Flow Through a Model of One Cooling-Water Passage of Tunnel E-2 Throat Block.** Jack A. Durand. *USAF AEDC TN-56-2*, Apr., 1956. 26 pp. Results of tests for the determination of the volume flow of water as a function of inlet pressure, pressure drop through the passage, flow direction, and surface roughness of the passage.

**Linearized Theory of Wind Tunnel Interference at Transonic Speed.** Toshimitsu Murasaki. *J. Japan Soc. Aero. Eng.*, Feb.-Mar., 1956, pp. 1–5. 17 refs. Theoretical study using the linearized theory extended to the three-dimensional lifting case at sonic and nearly sonic speeds, and applicable to the nonlifting case in the field of Mach Number near one with boundaries at finite distances.

**Investigation of the Use of the Thermal Decomposition of Nitrous Oxide to Produce Hypersonic Flow of a Gas Closely Resembling Air.** Appendix A—**Ideal Decomposition Temperatures.** Appendix B—**Chemical Analysis of Reaction Products.** Alexander P. Sabol and John S. Evans. *U.S., NACA TN 3624*, Mar., 1956. 36 pp. 14 refs.

**A Free-Flight Wind Tunnel for Aerodynamic Testing at Hypersonic Speeds.** Alvin Seiff. *U.S., NACA Rep. 1222*, 1955. 17 pp. Supt. of Doc., Wash. $0.20. Analysis of the Ames Lab. tunnel in which aerodynamic test models are gun-launched at high speed and directed upstream through the test section. Mach Numbers up to ten are attained, and aerodynamic measurements are made from photographic observation of model flight. Description of the apparatus developed for measuring drag, initial lift-curve slope, initial pitching-moment-curve slope, center of pressure, skin friction, boundary-layer transition, damping in roll, and aileron effectiveness.

**The A.R.A. Tunnel; A Co-Operative Research Facility for the British Industry.** *Flight*, May 4, 1956, pp. 534–539, 547.

**Der Windkanal am Indian Institute of Science, Bangalore, Süd-Indien.** Oskar Tietjens. *ZFW*, Jan.-Feb., 1956, pp. 6–9. In German. Description of the Indian Dept. of Aero. Eng. wind tunnel which has a very uniform velocity distribution, a very low turbulence level, and a capacity for engines and gas turbines. The general wind-tunnel requirements are discussed.

**Automatic Data-Accumulation System for Wind Tunnels.** J. J. Wedel, A. Huntington, and M. B. Bain. *IRE Trans., EC Ser.*, Mar., 1956, pp. 7–11. Design of a high-speed system, with details of a data recording process that increases the wind-tunnel pace, eliminates intermediate data handling before computation, and lowers the cost of data reduction.

**On-Line Automatic Data Reduction Tunnel E-1, Gas Dynamics Facility.** C. L. Hall and R. E. Klautsch. *USAF AEDC TN-56-4*, Apr., 1956. 28 pp. Description of a system capable of measuring, scanning, computing and presenting the results of a wind-tunnel test in one continuous operation. Operating modes of the system components are described as they apply to an actual test, and versatility, reliability, efficiency, and possible refinements are discussed.

**Mechanical Design and Fabrication of Strain-Gage Balances.** Raymond M. Hansen. *8th NATO AGARD Wind-Tunnel and Model-Testing Panel Meeting, Rome, Feb. 20-25, 1956, Paper.* 16 pp. Analysis of design concepts applicable to the floating-frame type of sting balances and to those used external to the model, in terms of economy and accuracy in obtaining aerodynamic data.

**Special Applications of Strain-Gage Balances Used in the Supersonic and Hypersonic Wind Tunnels at the U.S. Naval Ordnance Laboratory.** James R. Lightfoot and Charles E. White. *8th NATO AGARD Wind-Tunnel and Model-Testing Panel, Rome, Feb. 20–25, 1956, Paper.* 14 pp.

**Étude Expérimentale des Écoulements Gazeux.** Marie Merle. *France, Min. de l'Air PST 308*, 1956. 90 pp. 41 refs. In French. Experimental study of the flow of gases, with an evaluation of existing flow visualization techniques.

**Chronophotographie Stéréoscopique de Particules en Suspension Dans un Écoulement Aérodynamique.** A. Girard and E. Robert. *La Recherche Aéronautique*, Jan.–Feb., 1956, pp. 31–39. In French. Development of a visualization technique to study the trajectory of particles in subsonic flow.

**Investigation of a Multiple-Source Schlieren System for Application to a Perforated Wall Wind Tunnel.** M. Pindzola and G. R. Mozer. *USAF AEDC TR-56-1*, Apr., 1956. 27 pp. Derivation of visibility equations indicating the influence of geometrical parameters on the background pattern first for one and then for two tunnel walls. Includes an analysis of the application of the system to observation of flow disturbances through transparent material of poor optic quality, and an examination of an external source plate to increase system sensitivity.

**Design and Construction of Wind Tunnel Models.** Joseph J. Muncey and David M. Pote. (*Cornell Aero. Lab., Paper.*) *8th NATO AGARD Wind-Tunnel and Model-Testing Panel Meeting, Rome, Feb. 20–25, 1956, Paper.* Discussion of methods and techniques used, with particular reference to accuracy and minimum time, and with consideration of type and size of models, location and installation of strain gages and pressure orifices, and strength and rigidity of model materials.

**The Design and Testing of Supersonic Flutter Models.** John F. McCarthy, Jr., and Robert L. Halfman. (*IAS 23rd Annual Meeting, New York, Jan. 14–27, 1955, Preprint 513.*) *J. Aero. Sci.*, June, 1956, pp. 530–535, 577.

**Fabrication de Maquettes a l'Aide des Matières Plastiques.** G. Dixmier. (*France, ONERA NT 33*, 1956.) *8th NATO AGARD Wind-Tunnel and Model-Testing Panel Meeting, Rome, Feb. 20–25, 1956.* 61 pp. In French. Development of a method for the fabrication of dynamic models using reinforced plastics and taking into account similar properties of hydrodynamic models to satisfy heavy test conditions and to obtain dimensional stability, load resistance, degree of freedom, and surface finish.

**A New Standard for the Prediction of Full Scale Spin and Recovery Characteristics from Model Tests.** T. H. Kerr. *Gt. Brit., RAE Rep. Aero. 2538 (Revised)*, Jan., 1956. 18 pp. Evaluation of spin and recovery predictions by comparison of several model and full-scale aircraft, considering the following parameters: the nondimensional rate of rotation of the spin, the thickness to chord ratio of the wing, and the ratio of the moments of inertia in pitch to moments in roll.

**Rolling Power Measurements and Comparative Calculations for a Flexible Model Wing Constructed from Xylonite.** N. C. Lambourne, A. S. Batson, and A. Chinneck. Appendix—**Application of Lifting Line Theory.** H. C. Garner. *Gt. Brit., ARC R&M 2895* (Feb., 1952), 1955. 35 pp. 12 refs. BIS, New York. $2.15. Theoretical and experimental investigation using the Collar-Broadbent method, based on strip theory, and the Garner method, based on lifting-line theory, including results of two early and more approximate methods.

# Aeronautical Reviews — BOOKS

## ACOUSTICS

**Noise-Reduction Manual.** P. H. Geiger. Ann Arbor, Michigan University Press, 1955. 167 pp., tables. $4.00.

Originally prepared under the auspices of the Office of Naval Research, this book presents a brief but comprehensive treatment of noise reduction from a practical viewpoint. Proceeding from a general outline of the subject, it discusses techniques and devices for measurement of noise, insulation and absorption, vibration damping, and vibration isolation. As intended, it should be useful to those engaged in solving practical problems of noise reduction; its immediate purpose is to assist in training personnel at Naval Shipyard and Laboratory activities.

## AERONAUTICS, GENERAL

**Aviation Facilities;** The Report of the Aviation Facilities Study Group, Under the Direction of William Barclay Harding, to the Director, Bureau of the Budget. Washington, D.C., December 31, 1955. 46 pp., illus., diagrs.

This is a report undertaken at the request of the Director, Bureau of the Budget. It was instituted to evaluate the requirements and eventually to help solve the problems of aviation in the next decade or two. The recommendations include (1) a need for long-range study of aviation facilities and navigation aids, (2) the extent of the scope of the study in specific areas and subjects which require particular attention, and (3) the method of organizing and conducting the research. On February 11, 1956, President Eisenhower announced the appointment of Edward P. Curtis, Vice-President, Eastman Kodak Company, to the position of Special Assistant to the President for Aviation Facilities Planning.

## AIRPLANES

**How Airplanes Are Made.** David C. Cooke. New York, Dodd, Mead & Company, 1956. 72 pp., illus., diagrs. $1.95.

The dedication of this book reads, "To the boys of today who will build the planes of tomorrow." Especially designed for readers 8 to 12 years old, the material is predominantly pictorial. Each full-page photograph has a concise description of the process involved. From the moment the idea for a new model is born until the time the finished plane is rolled out of the factory for its first flight, the youngster will see exactly how an Air Force bomber is made.

## BLUEPRINTS

**A Simple Guide to Blueprint Reading, with Applications to Aircraft.** William N. Wright. Rev. Ed. New York, McGraw-Hill Book Company, Inc., 1956. 120 pp., illus., diagrs. $5.00.

A book intended primarily for those beginning the study of blueprints. The first edition appeared in 1941 with the title *A Simple Guide to Blueprint Reading*. Abbreviations and complex expressions have been avoided, and the explanation of the rules has been kept simple.

## ELECTRONICS

**Closed-Circuit and Industrial Television.** Edward M. Noll. New York, The Macmillan Company, 1956. 230 pp., illus., diagrs., tables. $4.95.

A discussion of the available closed-circuit systems and suggested ways in which such systems can serve modern needs. The first chapter describes operations and services that are already being performed by closed-circuit systems and provides many practical examples. The remainder of the book stresses the technical phases—systems, types of cameras and viewers, circuits and techniques, installation, and service. The final chapter presents sufficient construction details for the technician to construct a small inexpensive television camera. *Closed-Circuit and Industrial Television* can be used as a text in technical institutes and in adult education for courses covering the principles of television transmission.

## FLIGHT TESTING

**Proceedings of the First National Symposium on Flight Test Instrumentation, Wichita, Kan., May 3–5, 1955.** Presented by the Wichita Section, Instrument Society of America with the Cooperation and Cosponsorship of the National Technical Committee of the Instrument Society of America. Wichita, Kan., Harold T. Noble, Jr., Chairman, Symposium Publicity Committee, 2348 N. Roosevelt, 1955. 148 pp., illus., diagrs.

Contents: High-Speed Temperature Recording System, Jack A. Petersen. A Flight Test Instrumentation System for the Acquisition and Reduction of Quasi-Static Data, A. T. Snyder and R. M. Strassner. Centralized Automatic Data Instrumentation Facility, CADIF, G. T. Litton. Calibration Technique for Strain Gage Loads, W. L. Howland. The Effects of Temperatures Encountered in High-Speed Flight on Strain Gage Load Circuits, John K. Stotz, Jr. In-Flight Airload Determination, Niels Y. Andersen. The Application of Automatic Logging Techniques to the Structural Loads Calibration Process, Fred Sheehy and Hamilton Wilkins. Accuracy of Airborne Measurements and Calibration Techniques of Magnetic Tape Recording Instruments, Gromer L. Davies. An In-Flight Calibrator for Airborne Recording of High Impedance AC Signals, Lawrence W. Sherman. An Exploration in Magnetic Tape Recording for Aircraft Flight Testing, Walter J. Gabriel. An Integrated System for the Recording of Precision Data on Magnetic Tape, R. L. Sink. Remarks on Digital Recording, Eugene Peterson. Tape Recorder Developments Under Project Datum, Jerome J. Dover. Use of Telemetry to Make Magnetic Recordings on the Ground, John North.

## FUELS

**Fuel: Solid, Liquid, and Gaseous.** J. S. S. Brame and J. G. King. 5th Ed. London, Edward Arnold (Publishers) Ltd., New York, St. Martin's Press, 1955. 551 pp., illus., diagrs., tables. $7.66.

The work is intended to serve as a broad introduction to fuel technology and to give the necessary guidance for further study. It is limited strictly to the properties of fuels and their methods of application and does not include the details of processes of production or utilization of fuels. Major emphasis is placed on coal, petroleum, and gaseous fuels produced by various processes, only three chapters being concerned with petroleum derived fuels for internal combustion engines.

## INSTRUMENTS

**Frequency Response.** Edited by Rufus Oldenburger. New York, The Macmillan Company, 1956. 372 pp., illus., diagrs. $7.50.

From basic theory to experimental techniques, the entire field of frequency response is covered under nine broad chapter headings: (1) Fundamentals; (2) Frequency-Response Aids; (3) Servo, Airplane and Power System Applications; (4) Process Control; (5) Transient Response; (6) Optimum Controls; (7) Nonlinear Techniques; (8) Sampling Controls; and (9) Statistical Methods. The material consists of 18 papers and addresses, including discussions, presented at the 1953 A.S.M.E. Frequency Response Symposium, plus ten additional articles. Two of the articles, by L. C. Goldfarb and Ya. Z. Tsypkin, were originally published in the Soviet journal, *Avtomatika i Telemekhanika*. The features of the book include a discussion and criticism of each A.S.M.E. paper, an eight-page bibliography (by A. M. Fuchs), and subject and author indexes.

Contents: The Regeneration Theory, H. Nyquist. Early History of the Frequency-Response Field, A. C. Hall. The Frequency-Response Method—A Brief Survey, R. H. Macmillan. Frequency-Response Data Presentation, Standards and Design Criteria, R. Oldenburger. A Bibliography of the Frequency-Response Method as Applied to Automatic-Feedback-Control Systems, A. M. Fuchs. Analysis of Regulating Systems with Particular Reference to Speed Control, R. H. Macmillan. Frequency-Response Computational Aids, K. Izawa. Sine-Wave Generators, D. W. St. Clair, L. W. Erath, and S. L. Gillespie. The Frequency-Response Approach to the Design of a Mechanical Servo, H. A. Helm. Application of Frequency-Analysis Techniques to Hydraulic Control Systems, A. C. Hall. Frequency-Response Method Applied to the Study of Turbine Regulation in the Swedish Power System, V. Oja. Experimental Flight Methods for Evaluating Frequency-Response Characteristics of Aircraft, G. A. Smith and W. C. Triplett. Control-System Behavior Expressed as a Deviation Ratio, J. M. L. Janssen. Frequency-Response Analysis and Controllability of a Chemical Plant, A. R. Aikman. Frequency-Response Analysis of Continuous Flow Systems, H. Kramers and G. Alberda. Response and Phase-Lag of Thermometers, E. G. J. Eykman and C. J. D. M. Verhagen. Determination of Transient Response from Frequency Response, A. Leonhard. The Use of Zeros and

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Poles for Frequency Response or Transient Response, W. R. Evans. A Method of Estimating Dynamic Characteristics of Physical Systems, S. Lees. A Uniform Approach to the Optimum Adjustment of Control Loops, R. C. Oldenbourgh and H. Sartorius. Synthesis of Optimum Feedback Systems Satisfying a Power Limitation, J. H. Westcott. On Some Nonlinear Phenomena in Regulatory Systems, L. C. Goldfarb. Recent Advances in Nonlinear Servo Theory, J. M. Loeb. Approximate Frequency-Response Methods for Representing Saturation and Dead Band, H. Chestnut. Stability Characteristics of Closed-Loop Systems with Dead Band, C. H. Thomas. Frequency Method of Analyzing Intermittent Regulating Systems, Ya. Z. Tsypkin. The Pulse Transfer Function and Its Application to Sampling Servosystems, R. H. Barker. A Statistical Approach to Servomechanisms and Regulators, M. J. Pélegrin.

**Guide to Instrumentation Literature.** W. G. Brombacher, Julian F. Smith, and Lyman M. Van der Pyl. (U.S., National Bureau of Standards, Circular No. 567.) Washington, D.C., U.S. Government Printing Office, December 14, 1955. 156 pp. $1.00.

This guide to sources on instrumentation in the various sciences and technologies lists over 1,200 references. It functions both as a bibliography and as a bibliography of bibliographies. The book section, which comprises about half the listings, refers the reader directly to books on the subject. The references to abstract journals, indexes, handbooks, patents, and periodicals only allude to potential sources of articles and will necessitate further research on the reader's part. Within the sections, references are listed according to subject. Foreign language materials are not covered as thoroughly as those in English. One section is devoted to Guides to Technical Literature, a listing of books that tell how to search technical literature. A subject index augments the usual author index. The project is the result of the program of instrumentation research and development which is cooperatively sponsored at the National Bureau of Standards by the Atomic Energy Commission, the Office of Naval Research, and the Air Research and Development Command.

## LUBRICATION

**Bearing Lubrication Analysis.** R. R. Slaymaker. New York, John Wiley & Sons, Inc., 1955. 108 pp., illus., diagrs., tables. $5.00.

Written for the machine designer rather than for the lubrication specialist, this book covers the general principles of lubrication analysis in bearing design. The intention is to provide the insight needed to design actual bearings for simple cases and to handle the important preliminary planning for more complex applications where a bearing specialist will later be consulted. Its discussion is fully illustrated with case studies and numerical examples. There is a useful outline of hydrodynamic theory as a guide to the design of bearings lubricated from an external source, a discussion of the characteristics of various bearing materials, and an analysis of the so-called oilless bearings intended to perform without an external supply of lubricant. The book stresses sleeve bearings, and oil viscosity is also emphasized. A method is presented of predicting temperature rise and oil viscosity in one operation, which eliminates trial-and-error solutions.

**Theory and Practice of Lubrication for Engineers.** Dudley D. Fuller. New York, John Wiley & Sons, Inc., 1956. 432 pp., illus., diagrs. $10.50.

Basic concepts are systematized and generalized in the manner which the author, Professor of Mechanical Engineering at Columbia University, has found most practical in his teaching experience. Primary objectives of the book are to demonstrate, through the use of many examples, the wide usefulness of lubrication analysis in solving engineering problems and also to clarify the restrictions and modifications of lubrication theory that are vital to its successful application. Direct references are made to outstanding examples of recent research in lubrication. The techniques used and results achieved are included in the discussions.

Contents: (1) Fundamentals of Viscosity and Flow. (2) Viscosity and Its Variables. (3) Hydrostatic Lubrication. (4) Hydrostatic Squeeze Films. (5) Hydrodynamic Lubrication. (6) Hydrodynamic Lubrication of Journal Bearings. (7) Friction and Power Losses in Journal Bearings. (8) Some Typical Industrial Bearings. (9) Air-Lubricated Bearings. (10) Dry Friction. (11) Boundary Friction. (12) Bearing Materials.

## MATHEMATICS

**Elementary Differential Equations.** William Ted Martin and Eric Reissner. Cambridge, Mass., Addison Wesley Publishing Co., Inc., 1956. 270 pp. $5.50.

An introductory book on differential equations which is intended for science and engineering students. The authors present two major aspects for a study of the subject. One is concerned with the translation of problems from the fields of science and engineering into mathematical equation form. The other has to do with ways of solving the mathematical equations in order to extract information of interest from them. Included are many relatively simple examples on the formulation of scientific and engineering problems as differential equations.

## MATERIALS

**Metal-to-Metal Adhesives for the Assembly of Aircraft.** Richard G. Newhall, Editor. San Francisco, Western Business Publications, 1955. 63 pp., illus., diagrs., tables. $4.00.

These papers, published here in substantially their original form, were presented at a conference held on September 9–10, 1954, at the University of California under the sponsorship of the University and of the Aircraft Industries Association of America, Inc.

Contents: Factors Influencing Bonding Techniques, John Delmonte. Extrusion Coating, P. L. Jurisich. The Preparation of Aluminum Alloys for Adhesive Bonding, J. F. Murphy. Inspection Method for Metal-Metal Adhesive Bonds, H. R. Merriman. Sandwich Panel Attachments, T. P. Pajak. Design Details, A. M. Schwartz. Six Edge Designs for Airframe Sandwich Parts, J. O. Laws. Investigation of Aluminum Sandwich Beam Construction under Uniform Lateral Loads, J. C. Joanides. An Evaluation of the Stresses in Bonded Plastic Laminate Lap Joints, N. C. Myers. Design Considerations for Sandwich Construction, R. W. Spencer. Experience with Metal Adhesive Bonded Assemblies in B-36 Airplanes, D. A. Tooley. Advantages and Disadvantages of Adhesive Bonded Honeycomb Structure, C. F. Linkley.

**11th Annual Technical and Management Conference held by the Reinforced Plastics Division of the Society of the Plastics Industry at Atlantic City, N.J., February 7–9, 1956.** New York, The Society, 1956. 369 pp., illus., diagrs., tables. $5.00.

The 18 sessions of the conference are represented by 80 papers covering the following aspect of plastics: (1) strength-time behavior of reinforced plastics, (2) industrial design, (3) marketing and management, (4) plastics for tooling, (5) manufacturing, (6) engineering design, (7) premix, (8) materials and equipment, (9) cost and safety, (10) processing, and (11) transportation. The book includes two useful features: a biographical sketch section, alphabetically arranged, giving a brief professional history of panel members; and an abstract section, giving a brief résumé of the papers presented.

## METALS AND ALLOYS

**The Properties of Aluminium and Its Alloys.** 4th Ed. (ADA Information Bulletin No. 2.) London, Aluminium Development Assn., 1955. 204 pp., tables. 7*s.* 6*d.*

This edition is related to the 1955 revision of British Standards for Aluminium and Aluminium Alloys for General Engineering Purposes and also includes data for alloys as specified for aircraft use. The arrangement is such that all specified information concerning a particular form of material—e.g., castings, sheet, wire—is in one place, while any material can be found by its General Engineering number or its B.S. 'L' or D.T.D. number, as may apply. This revision also incorporates for the first time the proprietary names under which many compositions are supplied. Apart from their inclusion in the main data tables, British names in alphabetical order are listed in an Appendix; this shows the form in which each proprietary alloy is produced, its related (not necessarily identical) British Standard in the General Engineering Series, and the table number under which composition and properties are shown. The Appendix also lists selected oversea alloys showing in this case the nominal compositions; the relation of oversea alloys to British Standards has been avoided in order to obviate possible misinterpretation and confusion.

The book opens with a complete index of British Standards and Aircraft Specifications, followed by a brief classification of the main groups of aluminum materials. Tabulated data begin with the physical properties of aluminum and its alloys, and in this section are included weight calculations and factors. Following the 118 pages of main tables are notes on mechanical test requirements and test methods which define tensile properties, such as proof stress and elongation, and which include typical hardness values. The characteristics of aluminum as applied in particular forms or in certain fields are described under headings such as superpurity alloys, foil, electrical conductors, and sintered aluminum. Notes on characteristics affecting design include brief data on elasticity, strength in compression, shear stress, and bearing and fatigue strengths. Data on the properties of aluminum at elevated temperatures and on creep are followed by a note on properties at low temperature. General guides to alloy selection, dealing respectively with the castings and wrought materials, have been amplified and brought up to date.

**Casting Aluminum.** Reynolds Metals Company. Louisville, Ky., Reynolds Metals Company, 1956. 130 pp., illus., diagrs., tables.

The latest technical handbook in the Reynolds series provides an understanding of the design and production of aluminum castings. It includes concise information to help the designer select the casting process and the aluminum alloy best suited for the requirements of the product. Data on typical mechanical properties are also presented. Twenty-three tables offer information which includes chemical composition limits for the various alloys, typical mechanical properties at room and at elevated temperatures, and fabricating characteristics (weldability, machinability, etc.). Other tables present recommended cuts, feeds, and speeds for machining aluminum castings; typical heat treatments; typical core sand mixes; permanent-mold and die-casting tolerances for aluminum alloys; pattern maker's shrinkage for sand castings in various metals; and a comparison of weight of aluminum with equal volume of other metals.

## OPTICS

**Geometrical Optics.** L. C. Martin. New York, Philosophical Library, 1956. 215 pp., diagrs., tables. $7.50.

The author, sometime professor of Technical Optics, Imperial College of Science and Technology, London, has drawn upon many years of experience in teaching geometrical optics in setting up the general plan of the text. He aims at establishing a clear relation between geometrical optics and the relevant parts of physical optics and other branches of physics. Excluded are the uncertain approximations found in older books. The book should provide a sound foundation for the student proceeding to specialize in optical sciences or related subjects, and it demands only a modest mathematical equipment in analytical geometry and elementary calculus. A special feature is the chapter on the fundamental

theorems of photometry and their relation to practical problems.

### POWER PLANTS, ROCKET

**Theory of Combustion Instability in Liquid Propellant Rocket Motors.** Luigi Crocco and Sin-I Cheng. (AGARDograph No. 8.) London, Published for and on behalf of AGARD, NATO, by Butterworths Scientific Publications; New York, Interscience Publishers, Inc., 1956. 200 pp., illus., diagrs. $5.25.

This monograph stems from research of a broader interest being pursued under military contract at Princeton University. The objectives in the present work are (a) to establish a rational explanation for the existence of a detrimental and of a nondetrimental type of rough combustion, (b) to distinguish a number of mechanisms which may be responsible for the appearance of the detrimental type, (c) to give for some of these mechanisms plausible quantitative formulations, and (d) to analyze in detail the results of the theoretical developments. As in the case of earlier papers in this AGARD series, the authors are known for their earlier contributions in their fields.

Contents: (1) General Considerations. (2) Chugging Analysis (Low Frequency Instability). (3) Analysis of Screaming (Longitudinal High Frequency Instability). (4) Discussion and Comparison with Experiment. Appendixes. References.

### SPACE TRAVEL

**Secrets of Space Flight.** Lloyd Mallan. New York, Arco Publishing Company, Inc., 1956. 144 pp., illus., diagrs. $2.00.

A picture story of man's conquest of space, from past struggles to future probabilities. Material includes 292 photographs and was gathered during the author's 18,000-mile trip under military auspices.

### STRUCTURES

**Introduction to Plasticity.** Aris Phillips. New York, Ronald Press Company, 1956. 230 pp., diagrs. $7.00.

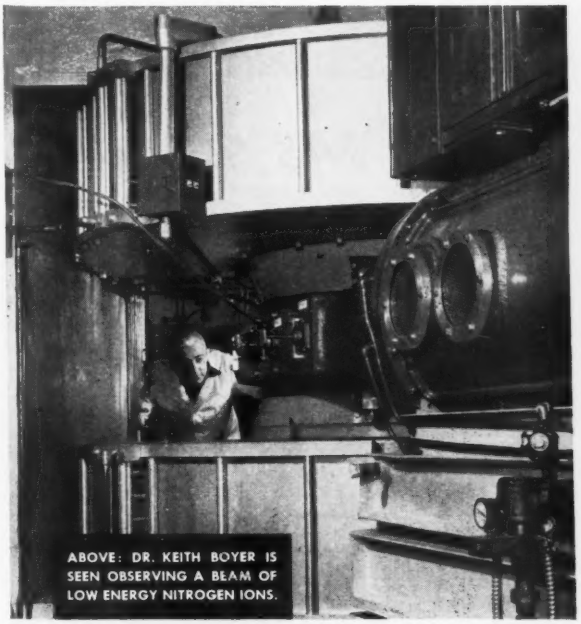
This is an introductory text on the subject of metal plasticity, written from the point of view of the stress analyst, and as an outgrowth of the author's lectures and researches on metal plasticity at Stanford University. The text is suitable for advanced undergraduate students and graduate students in engineering as well as for the practicing engineer. The mathematical tools employed are the minimum necessary for explaining the basic ideas of the theory of plasticity and for enabling the student to formulate and solve problems. The concept of a tensor, which is necessary only in advanced work, has not been introduced. The first six of the book's nine chapters deal with one-dimensional problems, and the last three consider problems of combined stress. Proofs of some of the theorems are given in the Appendix. Included are author and subject indexes. Each chapter contains its own bibliography. The author is now Associate Professor of Civil Engineering, Yale University.

Contents: The Calculation of the Collapse Load. The Moment-Curvature Diagram. Bending with Axial Force. Deflections. Curved Bars. Stress-Strain Relations. Collapse Under Combined Stresses. Strain Hardening Under Combined Stresses.

**Analysis of Statically Indeterminate Structures.** John I. Parcel and Robert B. B. Moorman. New York, John Wiley & Sons, Inc., 1955. 571 pp., diagrs., tables. $9.50.

Designed for use in and out of the classroom, this book covers both basic theory and its application to the more common types of structures. For classroom use, there are problems to be solved as well as a general plan for courses on different academic levels. In addition, the authors have tried to anticipate the needs of the person studying the book on his own. Mr. Parcel has been an engineering consultant as well as a teacher of structural engineering for many years; he is


BASIC RESEARCH at los alamos



ABOVE: DR. KEITH BOYER IS SEEN OBSERVING A BEAM OF LOW ENERGY NITROGEN IONS.

The cyclotron shown above is one of the many types of advanced research equipment in use at Los Alamos. This variable energy machine is designed to accelerate high intensity beams of all the hydrogen and helium isotopes.

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Vice-President, Sverdrup & Parcel, Inc., Consulting Engineers. Dr. Moorman is now Chairman, Civil Engineering Department, Syracuse University.

Contents: (1) Deflections by the Method of Work. (2) Deflections by Special Methods. (3) General Theory of Statically Indeterminate Stresses. (4) Special Methods—Selection of Base System—Elastic Center—Column Analogy. (5) Special Methods—Slope Deflection. (6) Special Methods—Moment Distribution. (7) Continuous Girders and Trusses. (8) The Rigid Frame. (9) Secondary Stresses. (10) The Elastic Arch. (11) Suspension Bridges.

**Plastic Strength of Structural Members; A Symposium.** (A.S.C.E., Paper No. 2772; Reprinted from A.S.C.E. Transactions, Vol. 120, pp. 1019–1164, 1955. New York, American Society of Civil Engineers, 1955. 145 pp., illus., diagrs., tables. $2.00.

The papers in this symposium relate to specific problems wherein plastic deformations are a determining factor in evaluating the strength of a structural member. The foreword notes some present and future uses of plasticity in relation to structural design.

Contents: Foreword, by the Committee of the Engineering Mechanics Division on Plasticity Related to Design. Plastic Deformation of Wide-Flange Beam-Columns, Robert L. Ketter and Edmund L. Kaminsky. Eccentrically Loaded, End-Restrained Columns, Paul P. Bijlaard, Gordon P. Fisher, and George Winter. Eccentrically Loaded Aluminum Columns, John W. Clark. Investigation and Limit Analysis of Net Area in Tension, W. Gordon Brady and Daniel C. Drucker.


## *IAS Twenty-Fifth Annual Meeting*

### Hotel Sheraton-Astor, New York City, January 28–31, 1957

The Meetings Committee plans to schedule sessions on Aerodynamics, Aeroelasticity, Design, Electronics, Flight Propulsion, Instruments, Rotating Wing Aircraft, Safety in Flight, Structures, Air Transportation, etc.

Members or organizations wishing to have papers considered for presentation at this meeting should submit outlines or short abstracts to the Meetings Committee, 2 East 64th St., New York 21, N.Y., no later than August 15, 1956.

## *Special IAS Publications*

| | Member Price | Nonmember Price |
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| **Aeronautical Engineering Index** – 1954 | $ 3.00 | $ 5.00* |
| 1953 | 2.50 | 4.00* |
| 1952, 1951, 1950, 1949, 1948, 1947 (each) | 2.00 | 3.00* |
| **Proceedings of the Second Turbine-Powered Air Transportation Meeting** (1955) | 3.50 | 6.00* |
| **Proceedings of the First Turbine-Powered Air Transportation Meeting** (1954) | 3.50 | 6.00* |
| **1955 National Telemetering Conference Record** | 3.50 | 3.50* |
| **1953 National Telemetering Conference Record** | 2.00 | 2.00* |
| **Fifth International Aeronautical Conference Proceedings** | 15.00 | 20.00* |
| **Second International Aeronautical Conference Proceedings** | 5.00 | 5.00* |
| **First and Second Convertible Aircraft Congress Proceedings** (each) | 3.00 | 5.00* |
| **Nineteenth Wright Brothers Lecture—Some Structural and Aeroelastic Considerations of High-Speed Flight,** R. L. Bisplinghoff (Reprinted from the April, 1956, JOURNAL OF THE AERONAUTICAL SCIENCES) | 1.00 | 1.50 |
| **Eighteenth Wright Brothers Lecture—Fatigue Life of Airplane Structures,** Bo Lundberg (Reprinted from the June, 1955, JOURNAL OF THE AERONAUTICAL SCIENCES) | 1.00 | 1.50 |
| **Index to Books on Selected Technical Subjects in the IAS Library (up to 1950),** unbound | 2.00 | 2.00* |
| **"Fifty Years of Flight"—A Chronicle of the Aviation Industry in America, 1903–1953,** Welman A. Shrader (Published by Eaton Manufacturing Company. Reprinting and Distribution Rights Granted to IAS) | 4.50 | 5.00 |

*Add $1.00 for orders outside the U.S.A.

*These may be obtained by writing to:*

**Publications Department, Institute of the Aeronautical Sciences, Inc., 2 E. 64th St., New York 21, N.Y.**

# Personnel Opportunities

**This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.**

## Wanted

**Aeronautical Engineer**—To teach courses in aeronautical engineering fundamentals. California State Polytechnic College, with an engineering enrollment of approximately 1,800 students and 70 staff members, offers an engineer the opportunity to work with students in a unique instructional program leading to a B.S. in Aeronautical Engineering. Practical experience in industry is of prime importance because instruction is based on a balanced combination of theory and practice. Teaching experience is desirable but not essential. If you have a Bachelor's degree or equivalent and up-to-date industrial experience, you can qualify for a starting salary of $5,000 to $5,500 for the academic year of approximately 9 months. Please send résumé of your education and experience and names of four references to: Dean of Engineering, California State Polytechnic College, San Luis Obispo, Calif.

**Physical Chemists**—Position available in physical chemistry for Ph.D. or engineer with equivalent education and experience in theoretical and experimental work in field of materials research. Ability required to perform studies and research in fields of organic and inorganic chemistry and physics of solids and fluids aimed at solving challenging problems of materials development for application in environments produced by hypersonic flight and nuclear reaction. Send résumé to: P.O. Box 949, Santa Monica, Calif., Attention: Barbara Magee.

**Aeronautical Research, Development, and Design Engineers**—GS-12 and GS-13 engineers needed for planning and testing work on propulsion and other fields. Minimum qualifications, B.S. degree plus 3½ years' experience depending on grade, including 1 year of specialized experience. Send completed Standard Form 57, Application for Federal Employment, to: Civilian Personnel Officer, Arnold Engineering Development Center, U.S. Air Force, Tullahoma, Tenn.

**The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.**

**Engineers**—Doak Aircraft Co., Inc., Torrance, Calif. (Los Angeles County), has a number of unusually interesting openings for aeronautical engineers in the design and development of a new vertical take-off aircraft. Challenging opportunities for men with experience and training in the fields of aerodynamics, structural design, stress analysis, mechanical design, and engineering drafting. The development of this VTOL aircraft is being conducted under a prime Government contract. Please send résumé including salary requirements to: N. E. Nelson, Chief Engineer, Doak Aircraft Co., Inc., 22309 South Western Ave., Torrance, Calif.

**Aeronautical Engineers**—The Navy Department, Bureau of Aeronautics, has a number of positions available in the following fields of aeronautical engineering including research and development on aircraft and guided missiles, structural loads, vibration and flutter, aerodynamic heating, power plants, cruise control, performance, ships installation of aircraft and missiles, and related mechanical, electrical, and electronic components. Salaries for most positions are at the GS-11, $6,390 per annum, and GS-12, $7,570 per annum, levels, although some positions may be available at the GS-13, $8,990 per annum, level. Positions require 2½ to 5 years' experience. Standard Form 57, Application for Federal Employment, should be sent to the Bureau of Aeronautics, Personnel Division (PE-202), Main Navy Building, Washington 25, D.C.

**Aeronautical Design Engineers**—The Aircraft Engineering Division of Lear, Incorporated, is offering outstanding employment opportunities to qualified aeronautical design engineers. Many employee benefits and advancement possibilities in this extremely progressive organization. Direct inquiries to: Kevin Keelaghan, Assistant Chief Engineer, Lear, Incorporated, Aircraft Engineering Division, Santa Monica Airport, Santa Monica, Calif.

**Engineers**—The Turbomotor Division of Curtiss-Wright Corporation is a new and rapidly expanding organization which will concentrate on the design and development of aircraft and missile propulsion systems in the low to medium power categories. Immediate openings exist for engineers qualified in the fields of compressor design, combustion, turbine design, mission analysis, and structural analysis. Starting salaries to $15,000, depending upon qualifications. A particularly attractive position currently available concerns the design and development of lightweight reduction gear trains and accessory drive arrangements. Also available is a supervisory position in the field of supersonic inlets. Send résumé to: Nicholas Vrabel, Turbomotor Division, Curtiss-Wright Corporation, 320 Fulton Ave., Hempstead, N.Y.

**Engineers**—Continuously challenging opportunities in long-range missile research and development programs offered to qualified engineers experienced in aerodynamics, structures, thermodynamics, electromechanics, or electronics. Company is moving into new $1,600,000 quarters in Santa Barbara, Calif., within the year. Send résumé to: Aerophysics Development Corporation (Studebaker-Packard Corporation subsidiary), P.O. Box 949, Santa Monica, Calif., Attention: Mae Ward, Personnel.

**Instructor**—The Department of Aeronautical Engineering at the University of Kansas has an opening for an instructor to teach the following: aircraft design; aeronautical laboratory courses in aerodynamics, instrumentation, propulsion, or structures; and other aeronautical courses. Appointment will be for 9 months starting

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September 1, 1956, and salary will depend on education and experience; advanced degree preferred. If applicant desires to pursue graduate study, arrangements may be made for part-time schedule. Résumé of education and experience should be furnished in initial reply. Apply to Chairman of Department of Aeronautical Engineering, University of Kansas, Lawrence, Kan.

**Aeronautical Engineers**—Princeton University, Department of Aeronautical Engineering, Helicopter Research Program, has positions available for qualified engineers. Opportunity is provided for responsible research in helicopter dynamics, including theoretical analyses and experimental work with models and full-scale machines. Openings exist on both the junior and senior engineering levels. These positions are academic appointments with corresponding University privileges, including 1 month's annual vacation, participation in graduate course work, and other benefits. Please send résumé to: L. Goland, Department of Aeronautical Engineering, Princeton University, Princeton, N.J.

**749. Instructor**—To teach aeronautical laboratory and aircraft vibrations in the Aeronautical Engineering Department of an eastern university. Master's degree preferred but not essential. Opportunity for graduate study and research

**748. Assistant Professor**—To teach aircraft propulsion in the Aeronautical Engineering Department of an eastern university. Master's degree and experience in propulsion desired. Opportunity for research and consulting.

**746. Mechanical Engineers, Turbomachinery**—Established manufacturer of small gas-turbine engines seeks engineers experienced in the production and assembly of high-speed turbomachinery for responsible positions in getting new production programs under way in the shop. B.M.E. degree preferred, plus at least 4 years' experience in engineering positions having intimate shop contacts—I.C. engines, fuel and oil pumps, high-speed turbomachinery, gearing, or closely related fields. Salary, $6,700–$10,500, depending on experience. Location, San Diego, Calif.

**745. Project Engineers, Small Gas-Turbine Development**—Established manufacturer of small gas-turbine engines has several openings for project engineers which constitute unusual opportunities for growth. Applicants should have ability to supervise others and to initiate design and experimental work, make sound engineering decisions, administrate project costs, make contacts with customers, and write clear reports. B.S.-M.E. or A.E. preferred, plus at least 5 years' experience in design, experimental, or project engineering work in a related field. Salary, $8,100–$12,000 a year, depending on experience. Location, San Diego, Calif.

**744. Project Engineer, All-Metal Honeycomb Sandwich Material**—Large manufacturer of airborne equipment seeks aggressive engineer to coordinate and spark the efforts of engineering, sales, and production departments in exploiting new structural material having enormous sales potential in fields of high-speed aircraft and missiles. Job will require customer contacts. B.S.M.E., A.E., or C.E. (Structures) preferred, with at least 4 years' experience in related fields such as aircraft structures design, empennage design, metallurgy or production of alloy steel structural components for aircraft, or combination of these. Salary, $8,100–$12,000 per year, depending on experience. Location, San Diego, Calif.

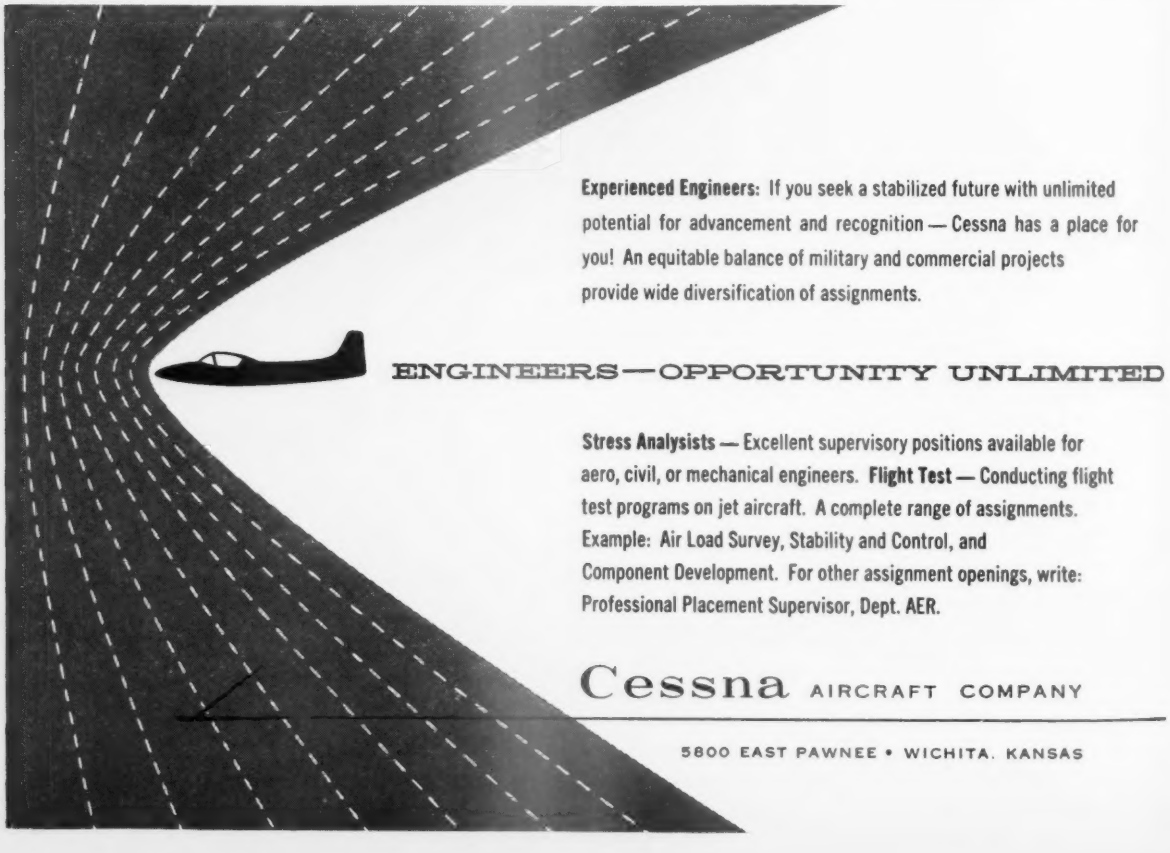
**743. Project Engineer, Aircraft Ducting Systems**—Large manufacturer of air-borne equipment seeks ambitious man to coordinate and spark the efforts of engineering, sales, and production departments in order to improve the company's performance in air-borne pneumatic ducting systems and components, already a profitable product line. Job will require customer contacts. Prefer B.S.M.E. or A.E. with at least 4 years' experience in design, manufacture, or application engineering of air-borne pneumatic components. Salary, $8,100–$12,000 per year, depending on experience. Location, San Diego, Calif.

## Available

**754. Communications Engineer**—Presently employed in the engineering department of an East Coast air-frame manufacturer. Desires to relocate in the West Coast area. Four years' experience in research on microwave vacuum tubes, cavity resonators, capacity adapters, and components; 3 years' experience in designing electronic installations in helicopters and jet aircraft. Additional service experience included responsibility for all electrical and instrument maintenance in Marine Corps helicopter squadron. Have also done technical illustration for publications.

**753. Mechanical Engineer**—B.S.M.E., M.S. Applied Mechanics. Five years' experience as project engineer in applied mechanics and materials engineering research, including experience in stress analysis, testing, creep, and high-temperature problems. One year of additional experience in design. Desires position in the field of aircraft or missile development.

**752. Administrative (Liaison, Representative)**—Twenty-five years' diversified commercial and military aviation experience involving sales and service, maintenance, overhaul and repair, flight operations, airport management inspection, contract school supervisor, domestic and international flying as military air-line pilot. Six years of USAF staff-level inspection (Inspector General) experience in staff coordination and supervision, troubleshooting, expediting, and elevating management efficiency. USAF Senior Pilot, CAA Commercial Pilot, A&E, ground in-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structor certificates. Liaison experience in manufacturing, contract carrier, and civilian contract school activities. Successful sales and business management background. Interested in industrial relations, customer relations, and military liaison. Desires a staff, administrative, or supervisory position where mature judgment and management ability are required. Progressive, flexible, assume responsibility. Age 46. Prefers connection with a company located in general area of Los Angeles or representation of a distant firm in a Los Angeles branch office. Résumé on request.

**747. Engineer**—Sales (Military-Commercial) and/or Administration. B.S. Mech. Engrg. Twenty years' experience in (1) aeronautical engineering (varied—missiles, piloted)—design, development, test, propulsion systems, aerodynamics, flight test; (2) sales—military and commercial; (3) industrial engineering. Six years with high-level U.S. Government agencies, U.S. and abroad. Currently chief engineer, foreign branch, U.S. organization. Speaks English, Spanish, French, Italian. U.S. citizen. Maximum security clearance. Pilot, former military air officer. Seeks appropriate position in U.S. or abroad. Prepared résumé will be sent prospective employers. Please do not send application first contact.

**742. Executive Engineer**—Sc.D. (Aero.), M. Aero.E., B.Aero.E., registered P.E., certified by National Board of Engineering Examiners. Ten years' extensive experience in structures research, flutter, vibration and shock analysis, and testing on fixed- and rotary-wing aircraft and rocket arming devices. Experience has been of a technical, as well as administrative supervisory, nature in research, dynamics, and structural analysis groups. Author of technical publications on vibration analysis and testing, creep, photoelasticity, and photothermoelasticity. Desires responsible position as Director of Research with a medium-size company or as an assistant to a top-level engineering executive of a large company. Will consider consulting position. Available October.

**740. Executive Administrator, Engineer**—Sixteen years' aeronautical engineering and administrative experience. For past 6 years has been manager of nationally operating aeronautical engineering concern which includes directing contacts (sales), publications, and technical representation. Experience with specifications and Government contracts. Age 39. Present salary $12,000 per year. Desires position in area near New York City.

**739. Aeronautical Engineer**—B.S. in M.E., M.S. in Ae.E., and M.Eng. in Ae.E. Ten years' experience in aircraft structures and design; presently engaged in aircraft preliminary design. Interested in a responsible position utilizing above experience.

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